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A RATIONALE AND STRUCTURE FOR INDUSTRIAL ARTS SUBJECT MATTER.
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THE INITIAL TASK OF THE PROJECT WAS TO INVESTIGATE THE STRUCTURE OF MAN'S KNOWLEDGE IN ORDER TO EVENTUALLY DEVELOP A DETAILED STRUCTURE OF KNOWLEDGE WHICH IS OF CONCERN TO INDUSTRIAL ARTS CURRICULUM PLANNERS. FOUR DOMAINS OF KNOWLEDGE ARE PROPOSED -- (1) DESCRIPTIVE, AS THE SCIENCES WHICH ESTABLISH FACTS ABOUT PHENOMENA AND EVENTS AND DESCRIBE THEIR INTERRELATION, (2) PRESCRIPTIVE, AS FINE ARTS AND HUMANITIES WHICH SEEK TO PROVIDE A SYSTEM OF VALUES, (3) PRAXIOLOGICAL, OR KNOWLEDGE OF PRACTICE WHICH IS CONCERNED WITH HOW MAN ACTS TO ACCOMPLISH WHAT IS VALUED, AND (4) FORMAL, DISCIPLINES SUCH AS MATHEMATICS AND LOGIC WHICH SERVE AS TOOLS. INDUSTRIAL PRAXIOLOGY IS THE APPROPRIATE CONCERN OF INDUSTRIAL ARTS. IT WAS ASSUMED THAT (1) INDUSTRIAL ARTS IS A STUDY OF INDUSTRY, (2) MAN HAS BEEN AND REMAINS CURIOUS ABOUT INDUSTRY, AND (3) INDUSTRY IS SO VAST A SOCIETAL INSTITUTION THAT, FOR INSTRUCTIONAL PURPOSES, EMPHASIS MUST BE PLACED ON A SYSTEM OF BASIC PRINCIPLES, CONCEPTS, AND UNIFYING THEMES. OTHER INDUSTRIAL ARTS CURRICULUM PROPOSALS AND SYSTEMS OF INDUSTRIAL CLASSIFICATION ARE EXAMINED IN AN EFFORT TO FIND A SOURCE OF KNOWLEDGE FOR INDUSTRIAL ARTS. THE STRUCTURE OF THIS KNOWLEDGE, DESIRED BEHAVIORAL CHANGE OR OBJECTIVES OF INSTRUCTION, THE NATURE OF THE LEARNER, SCHOOL FACILITIES AND MATERIALS, INSTRUCTIONAL PROCEDURES, AND PROGRAM EVALUATION ARE DISCUSSED. COMPANION DOCUMENTS ARE VT 003 145, VT 003 202, VT 003 204, AND VT 003 210. (EM)

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A Rationale and Structure for Industrial Arts Subject Matter

VT003283

IACP industrial arts curriculum project

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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A RATIONALE AND STRUCTURE FOR INDUSTRIAL ARTS SUBJECT MATTER

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A
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of
The Ohio State University
and the
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PREFACE

Increasingly, powerful social, political, and economic forces have been straining the cultural fabric of America with the result that every major social institution has felt their impact. Public education, because of its vital role, has been particularly affected. The magnitude and diversity of the pressures applied to the public schools has both quantitative and qualitative dimensions. In almost every community there is a demand for more and better education for students from all age, ethnic, and socioeconomic groups.

School personnel are responding to the great challenge of extending and improving educational services. Perhaps the most dramatic of these responses has been in the area of curriculum development. Curriculum specialists are discovering that by working collaboratively with teachers, school administrators, and content specialists, significant improvements can be effected in the quality of instruction. As a result of these cooperative efforts, many thousands of students today are studying mathematics, physics, biology, and other subjects in entirely new and exciting ways.

Industrial arts education, as a well established and vitally important curriculum area, also has been affected by this general thrust toward curriculum improvement. Concerned as they are with industrial processess, products, materials, and occupations, industrial arts personnel are increasingly aware of the growing gap between industrial reality and its representation in the total educational program. More particularly, it has become quite evident that many of the traditional approaches to industrial arts education are incapable of providing students with an adequate understanding of the impact of industry upon our man-made world and upon industrial personnel.

New curriculum designs have been proposed, and some experimental programs have been initiated. These have met with mixed acceptance and success. It is generally recognized that the central question involved in bringing about a major change in industrial arts education is the question of instructional content. That is, in view of the dynamic and complex character of modern industry, what are the appropriate units of instruction in industrial arts? If traditional courses in metalworking, woodworking, and drafting are no longer appropriate to the task, what is?

The Industrial Arts Curriculum Project (IACP), a joint effort of The Ohio State University and the University of Illinois, with financial support from the United States Office of Education, has undertaken to develop a rationale to guide the conceptualization of a more adequate structure or framework for the organized study of industry. The Project staff, consisting of professors and graduate research assistants from both institutions, is headquartered at The Ohio State University. It utilized the resources of both Universities, as well as consultants from other academic, industrial, and professional organizations. A distinguished Advisory Committee provided general guidance to the Project. With its counsel, the Project staff has developed a basic structure of the body of knowledge which it has defined as industrial technology.

This can provide a sound basis for the selection of content for industrial arts for use at any level of the educational ladder.

With the essential elements of the structure developed, a process which required approximately eight months, the Project staff then organized Task Forces of subject matter specialists to identify the more finite elements or subheadings which were needed to further detail the basic structure. These Task Force members were drawn from such substantive areas of industry as industrial design, industrial engineering, industrial psychology, and industrial organization and management. The Project staff drew together the products of the Task Forces into a document which, together with an opinionnaire, was then sent to leaders in education such as state and local supervisors, school administrators, teacher educators, and industrial arts teachers. Based on the reactions of this professional peer group and the Advisory Committee, a revised draft of the paper was prepared. The results of this developmental effort were disseminated through distribution of the basic document and through lectures at selected colleges and universities. Feedback from these dissemination procedures assisted the Project staff in further refining the proposed structure for the content of industrial arts.

After having developed the structure of the body of knowledge for industrial arts, the next step was the development of a position paper for the purpose of identifying the criteria for selecting learning experiences from a selected body of knowledge. The Project staff then organized a

Task Force to identify the major elements to be considered in selecting learning experiences. Consultants were employed to develop the major segments of this paper in accordance with the guidelines developed by the Task Force. This effort resulted in a listing of criteria to be considered in the development of the syllabus.

The next step was the development of a syllabus which includes: 1) a detailed listing of daily objectives for the first-year course in construction; 2) the development of the daily teaching program consisting of (a) the topical text outline, (b) programmed workbook, (c) teacher presentation, (d) laboratory activities, (e) laboratory manual, and (f) evaluation; and 3) detailed outline of daily text reading assignments.

During the next phase of the Project, it is anticipated that these materials will be developed through an instructional systems approach into an integrated package. This program will then be introduced in selected experimental centers throughout the nation, with in-service workshops and curriculum consultants from the Project staff aiding the local teachers and administrators. A thorough evaluation of these experimental programs would be conducted.

Summer institutes for teachers would be held parallel to the field testing of the materials. It is expected that a pre-service collegiate teacher education program would be designed to provide future industrial arts teachers with the new orientation and the requisite knowledge and skills. .

The Industrial Arts Curriculum Project undertook the systematic development of a structure for the body of knowledge from which industrial arts content logically can be derived and of a consistently derived syllabus. If this total effort is successful, industrial arts as a curriculum area will have a cohesive, comprehensive, and internally consistent framework from which students can draw meaningful insights into that complex and productive societal enterprise--modern industry. The benefits of such insights in terms of enlightened citizenship, educational-occupational guidance, and integration with the culture and the world of work would indeed be substantial.

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Chapter I

Praxiology as a Realm of Knowledge

Man's accumulated knowledge, increasing at an accelerating rate, is vast in scope and heterogeneous in nature. It is not economically feasible to deal with this amorphous mass without structuring it into logical divisions. Thus, for various reasons, knowledge has been subdivided into more manageable divisions which are functional, for one reason or another. It may be postulated that one such division would include man's knowledge of how to do things efficiently. Without such knowledge, the world of work would be chaotic.

The initial task of this Project was to investigate the structure of the totality of man's knowledge with the immediate objective being to identify a logical basis for structuring man's knowledge of how to achieve efficiently a practical purpose. Only then could the ultimate objective of the first phase of this project be approached, the development of a detailed structure of that smaller segment of the knowledge of practice which is of particular concern to industrial arts curriculum planners.

This Chapter reports the findings of the above investigation. It further attempts to place in an adequate educational perspective all school subjects which are based upon the applied disciplines. Again, the ultimate purpose was to place industrial arts appropriately within this context.

In subsequent Chapters of this document the sub-elements of the knowledge of practice are identified, the place of industrial knowledge among these sub-elements is determined, a structure of industrial knowledge is conceptualized and developed in detail, a rationale for the selection and organization of structure-based learning activities is presented, and a detailed syllabus is outlined for a first year course. From this would follow the development of other syllabi and years of experimentation, refinement, and school and teacher education implementation. This document deals only with one phase of a total project to the point where the body of knowledge is conceptualized, structured, and organized into a one-year syllabus. Planned subsequent activities are briefly described in the Preface.

In the Project proposal, three assumptions were made as to the nature of industrial arts:

1. Industrial arts is a study of industry. It is an essential part of the education of all students in order that they may better understand their industrial environment and make wise decisions affecting their occupational goals.
2. Man has been and remains curious about industry, its materials, processes, organization, research, and services.
3. Industry is so vast a societal institution that it is necessary, for instructional purposes, to place an

emphasis on conceptualizing a fundamental structure of the field, i.e., a system of basic principles, concepts, and unifying themes.

Further assumptions were made as the study progressed:

1. For purposes of analysis, man's knowledge can be categorized and ordered logically.
2. To provide for the most effective and efficient transmission of knowledge, the educator must codify and structure disciplined bodies of knowledge.
3. The structure of a body of knowledge can be developed before the total curriculum is designed.
4. All domains of man's knowledge must be included in an effective general educational program.

In carrying on the Project, these assumptions dictated a search to determine if there is an identifiable body of industrial knowledge and, if so, its structure.

COMMON VIEWS OF MAN'S KNOWLEDGE

Two points of departure for investigating the knowledge of man and the systems into which it is structured are the organization of knowledge in (1) higher education and in (2) elementary and secondary education.

In Higher Education. Colleges and universities are generally recognized as fountainheads of knowledge. Communities of scholars search for answers to basic and applied problems; they develop, order, and record the accumulated bodies of knowledge by rules which govern their structure; they disseminate or transmit this knowledge to their students; and they provide services to the wider community. In addition, researchers in government (public sector) and business and industry (private sector) contribute significantly to this storehouse. Productive scholars exist in many facets of society.

Regardless of the source or character of the knowledge, it becomes one of the tasks of higher education to verify and codify this multitude of facts, principles, concepts, and values. Into what divisions might this knowledge be categorized logically? Attempts to classify or categorize the vast body of accumulated and recorded knowledge are difficult, since there is controversy as to the nature of knowledge and since knowledge is always in a state of development. Recognizing these difficulties, it seems necessary to examine some classification systems.

Aristotle, the first great systematizer, named three classes: (1) the theoretical disciplines, (2) the practical disciplines, and (3) the productive disciplines. The theoretical disciplines were mathematics, natural sciences, and metaphysics. The practical disciplines encompassed ethics, politics, and human conduct. The productive disciplines included the fine arts, the applied arts, and engineering (McKeon, 1947).

Knowledge gradually was perceived to be restricted only to the sciences and mathematics of Aristotle's theoretical disciplines. Consequently, in the nineteenth century, Auguste Comte, father of modern positivism, proposed a scheme of classification that was widely used as a substitute for that of Aristotle. His positive hierarchy of the sciences started with mathematics as the natural logic governing the study of all subject matter. After mathematics came, in order, physics, chemistry, biology, and the social sciences (Cassirer, 1950). This organization has had a tremendous influence on the teaching of science at both the collegiate and high school levels.

Many classifications of man's knowledge are still being proposed. A sample of contemporary thinking may be found in the writings of Hanna, Phenix, Tykociner, and Maccia.

Hanna points out the remarkable similarity of present-day classifications of knowledge in Western culture to that system of the ancient Chinese in which they spoke of man-to-thing, man-to-man, and man-to-spirit. These in turn relate to the natural sciences, the social sciences, and the humanities.

Hanna suggests that knowledge may be considered on a continuum where:

> At one end of the line we might identify logic and mathematics; at the other end, the humanities: the good (values, ethics, morality, religion, etc.) and the beautiful (music, art, architecture, literature, dance, etc.)
>
> In between these ends of the spectrum, but closer to the logic and mathematics, we might place the natural sciences: the physical sciences (physics, chemistry, astronomy, etc.), the biological sciences (botany, zoology, physiology, anatomy, etc.), and then those disciplines which draw from both physical and biological sciences (biochemistry, etc.).

> On the same continuum, but closer to the humanities end, we might group the social sciences (as does the Encyclopedia of the Social Sciences), thus: the more purely social sciences (political science, economics, history, jurisprudence, anthropology, penology, and sociology), and the semi-social sciences (ethics, education, philosophy, and social psychology), and finally three disciplines which are more accurately grouped with the natural sciences (social biology, medicine, geography) and the two disciplines which are more closely associated with the humanities (linguistics and art). We find these divisions utilized in many ways: universities typically group their undergraduate curriculum into the humanities, social sciences, and natural sciences. We have foundations, and journals, and professional associations that serve one or another of these three popular categories (Hanna, 1961, pp. 69-70).

Hanna thus rejects the positivistic restriction of knowledge to sciences and returns to the essentials of the Aristotelian classification.

Phenix (1964a) recognized six realms of meaning which emerge from the analysis of the possible distinctive modes of human understanding. These realms of meaning are: (1) symbolics, (2) empirics, (3) esthetics, (4) synnoetics, (5) ethics, and (6) synoptics. The symbolics include ordinary language, mathematics, and nondiscursive symbolic forms. Within empirics are the physical sciences, the life sciences, psychology, and the social sciences. The esthetics cover music, visual arts, arts of movement, and literature. The synnoetics encompass philosophy, psychology, literature, and religion in their existential aspects. Ethics is considered those varied special areas of ethical and moral concern. The last realm, synoptics, includes history, religion, and philosophy. Phenix, too, is Aristotelian in his classification but there is a notable omission of the applied arts and engineering.

Tykociner proposes a scheme which represents knowledge in its present state of growth and transformation. He thereby transcends the Aristotelian attempt and avoids one source of the difficulty in classifying knowledge mentioned earlier in the Chapter. In addition, he makes the claim that the system operates as "...a guide to find gaps in systematized knowledge" (Tykociner, 1964, p. 133). The following table summarizes the scheme:

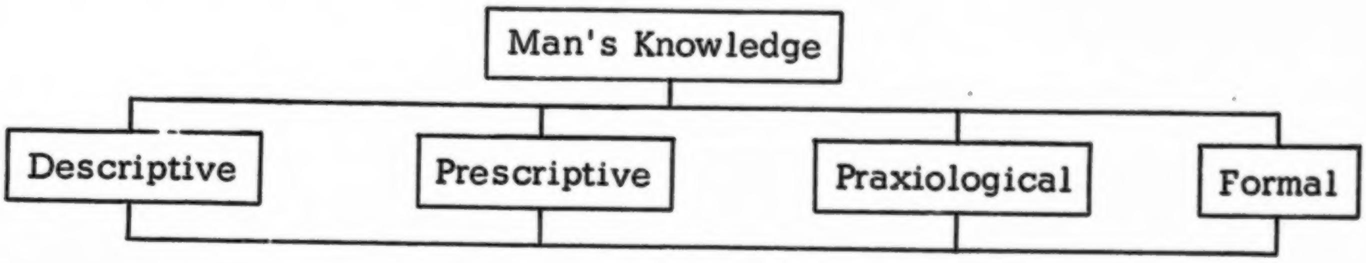
FUNCTIONS OF AREAS OF KNOWLEDGE
(Tykociner, 1964, p. 145)

Series	Areas of Knowledge	Function
I.	1. Arts 2. Symbolics of information	To develop systems of symbolic representation of perceptual and cognitive activity for purposes of communication
II.	3. Hylenergetics 4. Biological sciences 5. Psychological sciences 6. Sociological sciences	To systematize knowledge of basic facts and their relations
III.	7. Exeligmology 8. Pronoetics 9. Regulative sciences 10. Disseminative sciences	To systematize knowledge of the past, project future needs, and regulate activities
IV.	11. Zetetic sciences	To promote the growth of all the arts and sciences
V.	12. Integrative sciences	To create an all-embracing synthesis

The area named pronoetics is most similar to the domain of praxiology. These similarities will be more thoroughly pointed out in the next section of this Chapter.

In outlining her four principal classes of "speculation" of man, E. Maccia gives explicit recognition to praxiology. The classes of speculation obviously relate to the subsequent classes or categories of systematized knowledge. These types of speculation may be about *form*, *events*, *values*, and *practices*. Therefore, the scholar and researcher deals with formal theory, event theory, valuational theory, and praxiological theory. "Formal theory is speculation with respect to structures . . . Event theory is speculation with respect to occurrences . . . Valuational theory is speculation as to worthwhileness . . . Praxiological theory is speculation about appropriate means to attain what is taken to be valuable" (E. Maccia, 1965, pp. 4-5).

From the above four classes of theory, we propose four domains of man's knowledge. These are: (1) descriptive knowledge, (2) prescriptive knowledge, (3) praxiological knowledge, and (4) formal knowledge. These domains are depicted below:



The key term used to identify the first domain, descriptive knowledge, would be *sciences*. The sciences seek and establish facts about phenomena and events and describe their interrelation. Commonly recognized as major areas of study in institutions of higher education are such divisions as the physical sciences, biological sciences, and social sciences (or hominological sciences, E. Maccia and G. Maccia, 1962, p. 3). Each field in turn encompasses several recognized disciplines, e.g., physics and chemistry, botany and zoology, and anthropology and sociology.

The second domain or realm of man's knowledge is prescriptive knowledge. The fine arts and humanities seek to provide man with a system (or systems) of values--judgments as to whether phenomena or events ought to be--whether true and/or good and/or beautiful. Such fields of study as literature, philosophy, music, and art are commonly recognized as important divisions of prescriptive knowledge in higher education.

A third domain of knowledge could be described as knowledge of practice. This domain is represented in higher education by the various professional schools and departments. Among them would be medicine, journalism, law, engineering, marketing, education, dentistry, dairy technology, pharmacy, and many others. These so-called applied or derived fields of knowledge draw upon the formal, descriptive, and prescriptive domains as necessary but insufficient background for full status in the practicing profession. Practice per se, is necessary also for proper training but, even with formal, descriptive, and prescriptive knowledge, is not sufficient. These disciplines demand a clinical or professional body of subject matter. This body of knowledge is termed knowledge of practice (principles of practice) or praxiology--man's way of doing which brings about through efficient action what is valued (or ought to be).

The fourth realm or domain of man's knowledge could be termed formal knowledge. The disciplines within formal knowledge serve as tools which are used to order all knowledge and therefore could be abstracted out as the form or arrangement (syntactics) of the three categories presented above. Mathematics and logic are examples of fundamental disciplines recognized for these purposes by institutions of higher learning.

In Elementary and Secondary Education. The sciences (descriptive knowledge), the fine arts and humanities (prescriptive knowledge), and mathematics and logic (formal knowledge) have had the longest history and greatest degree of acceptance in formal school education. Even a cursory examination of school curricula, however, would indicate a somewhat incomplete and noncomprehensive approach to these three domains. For example, psychology, philosophy, and logic are not visible in the elementary and secondary school curriculum. Innovation and curriculum change are needed in these domains, but such recommendations are beyond the purpose and scope of this Project.

Praxiology (principles of practice) has been given less recognition in the formal school than have the descriptive, prescriptive, and formal domains. Historically, apprenticeship in the trades and crafts (education of an informal or non-school type) antedated the formal school. Several occupation or practice-oriented school subjects offer a study of selected practical arts of man. These have appeared in formal schools (in the U.S.A. mostly within this century) as agriculture, home economics, business and office occupations, distributive education, trade and industrial education, and industrial arts, for example. However, because of their recent occurrence on the school scene, and also because of their rapidly expanding and changing body of knowledge, they rarely have been organized and structured to attain the goal of a systematic coverage of man's knowledge of practice. Rather, they have been treated primarily as selected practical experiences (practice) together with related supporting principles of the formal, descriptive, and prescriptive domains of knowledge. Almost no attempt has been made to organize and order systematically the comprehensive body of knowledge of practice or efficient action in these fields. In spite of this condition, they have achieved a degree of success in the school curriculum, and in many communities one or more of them are required of all public school pupils.

A review of several recent statements regarding the content appropriate for school education will substantiate the above claims. Included in the brief review are writings of Bellack, Phenix, and Broudy, Smith, and Burnett.

Bellack reviewed the stated positions of four leading educational theorists, each representing a very different philosophical and educational orientation. He concluded that " . . . there is substantial agreement regarding the disciplines and broad areas to be included in the program for all students: the natural sciences, mathematics, social sciences and humanities" (Bellack, 1961, p. 47). Note that praxiological considerations are omitted.

At a later time, Bellack (1964) wrote that there is universal agreement that knowledge derived from organized inquiry is the stock-in-trade of the school. But he suggests that there also is general agreement that the school's responsibility extends beyond the organized realms of inquiry and learning. The school must meet the multitude of needs created by the society and culture. He recommends that study "in the round" is appropriate for the school where the teaching of specific cognate disciplines (e.g., social sciences) and broad areas of knowledge (sciences on the one hand, and the humanities on the other) are related to human problems and their solutions. Although implied by the phrase "human problems and their solutions," no explicit support is given to the study of knowledge of practice.

Phenix, in his book Realms of Meaning: A Philosophy of the Curriculum for General Education, makes the claim that:

> . . . the curriculum should at least provide for learnings in all six of the realms of meaning: symbolics, empirics, esthetics, synnoetics, ethics, and synoptics. Without these a person cannot realize his essential humanness. If any one of the six is missing, the person lacks a basic ingredient in experience. They are to the fulfillment of human meanings something like what basic nutrients are to the health of any organism. Each makes possible a particular mode of functioning without which the person cannot live according to his own true nature (Phenix, 1964a, p. 270).

It must be noted that Phenix indicates that these areas of knowledge are minimal for the school program. Later in his book he discusses the difference between general and specialized studies and between fundamental and the derivative or applied fields of learning.

Phenix concludes that general education develops the person in his essential humanity, and specialized education provides for particular competencies for purposes other than the development of a person as a person. "The significant distinction is between studies intended to develop _kinds_ of understanding (not _particular_ understandings) that _everybody_ needs simply because he is human and studies intended to develop kinds of understanding that only _some_ people need in order to fulfill certain particular individual or social ends" (Phenix, 1964a, p. 272).

With regard to the distinction between fundamental and derivative or applied fields of learning, Phenix writes:

> The term "fundamental" refers to fields that are concerned with the deliberate and direct pursuit of one of the six possible kinds of meaning . . . Derivative or applied fields, on the other hand, result from the utilization of meanings from the fundamental disciplines in the solution of problems arising out of biological and social exigencies. The fundamental studies focus on the pure types of meaning, having regard for their distinctive forms. Derivative studies grow out of practical considerations, and workers in them seek solutions to problems without regard to purity of logical type (Phenix, 1964a, p. 273).

That such organized bodies of practical knowledge exist is indicated by Phenix:

> Some disciplines are primarily devoted to understanding apart from the service of practical needs. Others are concerned mainly with application. Physics is an example of the former and engineering of the latter. Economics is a purely cognitive discipline, while marketing and insurance are practical or applied disciplines. History comprises pure knowledge; law deals with practical matters. Knowledge in the applied disciplines has structures, just as in the case of the theoretical disciplines. The practitioners of the applied disciplines also form

> identifiable communities of specialists. Similarly, the practical disciplines owe their existence to the fact that productive ways of organizing knowledge have been discovered. In these cases, however, the productivity is measured by success in dealing with the problems of practice (Phenix, 1964b, pp. 50-51).

According to Phenix, " . . . all curriculum content should be drawn from the disciplines . . . only knowledge contained in the disciplines is appropriate to the curriculum" (Phenix, 1962, p. 57). Since there are practical disciplines, it would follow therefore, by this argument, that the school could include elements of such study in the curriculum.

Broudy, Smith, and Burnett (1964) propose a design for a common curriculum for grades seven through twelve. They suggest five major categories: (1) symbolic skills in language and mathematics; (2) basic concepts from general science, biology, chemistry, and physics; (3) developmental studies in three sets--Universe and Cosmos, Human Institutions, and Culture; (4) value exemplars from art, literature, philosophy, and religion; and (5) social or molar problems sampled in the last years of the high school.

Each category suggests subject matter fields and implies the disciplines from which they are drawn. However, the category of developmental studies may need further elaboration. The authors state:

> The basic sciences serve to organize and classify human knowledge as it now exists. When so taught and so learned, they can be used as cognitive maps to structure experience with order and some precision. What these sciences do not reveal is how our universe, our institutions, and our culture, that is, our technologies, our ideologies, our arts, and our sciences, came to be what they now are.

> Nor do they tell us what we need to know about those disciplines that are devoted to anticipating the needs of our society or to meeting its current problems; yet part of the cultural capital is that great stock of methods which have been developed for accumulating, storing, elaborating, and disseminating the culture. Finally, the basic sciences give only an inkling of man's efforts to make sense of life as a whole and to find a meaningful goal for it. The role of science in the human quest is a tribute to man's highest powers, but it does not justify the quest itself (Broudy et al., 1964, p. 201).

Within the developmental study sets, certain typical practical arts subjects such as industrial arts are given a prominent place, but with the admonition that such subjects, as presently taught, must undergo radical revision to serve the general education need. Of considerable importance would be units of study regarding the evolution of industrial technology and a knowledge of the major types of industrial processes with which man reshapes natural resources for his material needs.

PRAXIOLOGY--THE STUDY OF MAN'S PRACTICES

The most commonly held view of practice is that man does what he has been shown by an experienced person and, at most, applies some of the principles of theoretical knowledge in practical situations. By implication, therefore, the elements of practice cannot be ordered, taught, and studied. This view of the theory-practice dichotomy would support the teaching of "basic" or "fundamental" knowledge of the formal, descriptive, and prescriptive domains together with the planned application of these "fundamental" principles in practical experience. That such a position is memorialized by our continued reliance on internship and apprenticeship has been pointed out by Schwab (1964). For example, colleges of education rely heavily on "practice" teaching. In fact, student teaching consistently is rated by students as the most significant learning experience in professional education. "Methods" courses attempt to provide the "knowledge of practice."

One has but to look to the several praxiological disciplines at the collegiate level to find that there are recognized bodies of knowledge in law, engineering, medicine, and psychiatry, among others. These disciplines owe their existence to the fact that scholars have found ways of organizing such knowledge.

The term "praxiology" comes from the Greek _praxis_ meaning _to do_, or the practice of an art, science, or technical occupation. The suffix "ology," connoting a science or branch of knowledge, completes the full meaning: the knowledge (principles) of man's practices.

Kotarbinski defines praxiology as "the science of efficient action." He writes:

> . . . the tasks of praxiology are to formulate and to prove recommendations concerning what must be done: what it is advisable to do under definite circumstances in order to attain the intended results in the most efficient way.
>
> . . . In our endeavor to set apart praxiological theorems we shall have, first of all, to distinguish the essential theses of that discipline, as opposed to its auxiliary and secondary sentences. Now these essential theses are certain practical directives, that is, directives recommending as appropriate means those which lead to definite results (Kotarbinski, 1962, p. 211).

That praxiology represents more than the sum of the parts (formal, descriptive, and prescriptive knowledge), he continues:

> . . . The essential point is that the practical disciplines cannot remain satisfied with borrowing from strictly theoretical disciplines their theorems on relationships between events, but must themselves search for those relationships on which their own recommendations are to be based (Kotarbinski, 1962, pp. 219-20).

For example, a knowledge of practice may be codified that goes beyond the laws and principles, say, of physics or chemistry, as they relate to an industrial establishment. In support of this contention, one writer states: "Technologies founded on an application of science may form a scientific system of their own. Electrotechnics and the theory of aerodynamics are examples of systematic technology which can be cultivated in the same way as pure science" (Polanyi, 1964, p. 179).

The case herein made for the recognition of praxiology does not imply any de-emphasis of the descriptive, prescriptive, and formal domains of knowledge. These form, however, only a portion of the base upon which the praxiological studies rest, for the element of practical experience is critical. It must be pointed out that a "knowledge of practice" does not reduce the need for "knowledge" or for "practice." All three ingredients--(1) knowledge (knowledge of the formal, descriptive, and prescriptive domains), (2) knowledge (principles) of practice (knowledge of the praxiological domain), and (3) practice--are necessary for a complete educational program. For example, as a part of the study of industry in industrial arts, pupils might design a product, plan the production phases, and actually mass produce the product. Concurrently, they might study the knowledge of practice within the production boundary. Supporting the actual laboratory "practice" and the study of the "knowledge of practice" would be subjects from the formal, descriptive, and prescriptive domains (e. g., mathematics, physics, economics, and art).

NEED FOR THE DEVELOPMENT OF SCHOOL PROGRAMS BASED UPON PRAXIOLOGICAL DISCIPLINES

History indicates that the practical needs of man have forced him to efficient action; indeed, his survival has depended upon it. Thus, praxiology in many instances has preceded any formal, descriptive, or prescriptive foundation. The development of the steam engine antedated the formal study of thermodynamics. Conversely, the results of theoretical investigations have led to new practices or technics.

> That is, science arises as the codification and outgrowth of the accumulation of practical know-how. Science in turn gives birth to technology. Technology alters ourselves and the face of our world, thus creating new problems, calling for a new know-how, and therefore leading to new theoretical enquiries and new bodies of science (Schwab, 1964, p. 27).

The interdependence of "science" and praxiology is obvious. Organized education of both types holds the key to future progress. Together with prescriptive and formal knowledge, they provide the balance desired.

Law, medicine, and certain other praxiological disciplines were established before the nineteenth century. The land grant collegiate institutions in the nineteenth century provided impetus to the development of professions of practice in agriculture, the mechanic arts (which later was largely restricted to engineering), and national defense (military training). Colleges and universities have continued to provide and expand their offerings in the professions of practice. New discoveries in science and in the arts and humanities will further increase the need for formal higher education in the rapidly developing praxiological disciplines.

At the elementary and secondary school level, subjects of a practical type have developed principally since the turn of the century. Generally speaking, their subject matter has been derived from an analysis of a limited number of practices of the farmer, the homemaker, the businessman, and the custom tradesman.

The praxiological approach to this subject matter would be based upon a comprehensive analysis of the knowledge of the practices employed in agriculture, business, the home, and industry. Collegiate education in medicine, engineering, and many other practice-oriented studies has been based upon praxiology. The elementary and secondary school (and many junior college) programs have not. Selected skills (practices) and selected related information (theory) have shaped the character of these offerings. Therefore, subjects of this type have been "practice" oriented together with some supporting knowledge, which generally has been selected on a poorly-organized basis, from the formal, descriptive, praxiological, and prescriptive domains.

All pupils, especially the large group that will not enter or satisfactorily complete college, need education in basic fields of practical knowledge. However, major sources of difficulty have been the lack of: a viable structuring and categorization of the knowledge of practice, adequately conceptualized knowledge within each category, determination of the portion of praxiology which should be taught in the schools, and the necessary teaching-learning materials.

The task seems evident and clear. Attempts must be made to determine the basic and significant knowledge of man's total practices. This knowledge must be structured to permit effective and efficient transmission to pupils at the elementary and secondary school level.

The praxiological disciplines at the collegiate level are major but not all-inclusive sources of content for school studies in praxiology. Other practices of man, not well codified and not contained in collegiate offerings, provide fruitful sources. It remains for educators to discover those appropriate and generalizable insights and understandings that should be included as a common base for all students.

CONCLUDING STATEMENT

Each year in this country there are nearly a million high school dropouts and more than a million non-college-bound high school graduates. Approximately forty percent (40%) of all who enter college drop out before graduation.

> As a group these represent 75 to 80 percent of all our youth, and the educational preparation and occupational well-being

> of this group will in large measure determine the course of this nation in the difficult years ahead. As they leave school, they are ambitious, opportunity-seeking, and still idealistic. In the world of work, however, they are likely to be under-employed, if they find employment at all (Venn, 1964, p. 23).

What do they have in their background to provide them with the necessary knowledges and skills to contribute to the growth of the economy and maintenance of stable employment patterns? In today's rapidly changing world of work, the key saleable skills are flexibility and adaptability. An educational program based solely on the formal, descriptive, and prescriptive disciplines may not provide the necessary knowledges and skills for entry into the labor market. On the other hand, a secondary school program geared to isolated occupational practices which may be obsolete within a few years is remarkably inefficient. This point is amplified in the "Rockefeller Report on Education":

> In this day of technologies that become antiquated overnight, it is hazardous to predict a favorable future for any narrow occupational category. There will be economic advantage to the individual in acquiring the kind of fundamental training that will enable him to move back and forth over several occupational categories. Individuals so trained will find a market for their talents under most circumstances. Individuals more narrowly trained will be at the mercy of circumstances (Gardner, et al., 1958, p. 10).

A secondary school program which provides a study of the fundamental principles of practice (praxiology) together with selected practice and a broad theoretical base may meet the challenge of the future. Such a program would have built-in transfer of learning features which provide the flexibility so necessary for occupational, psychological, social, and economic adjustment. Moreover, it provides a basis for the development or acquisition of additional praxiological knowledge by each individual.

One final point should be made. When the body of praxiological knowledge is conceptualized into a meaningful structure for pedagogical purposes, it could serve many educational programs meeting special needs at various educational levels. For example, at the secondary school level, differential subject matter could be drawn from the body of praxiological knowledge for: (1) pupils receiving a common general education base, (2) pupils planning degree or non-degree post-high school education, (3) pupils seeking rather specialized occupational training, (4) uncommitted pupils in the "general" curriculum who need a generalized occupational education, and (5) atypical pupils requiring modified educational programs.

With the recognition of the role that praxiology has to play in the education of all young people, and especially of those not entering or succeeding in higher education, a more effective educational pattern at the school level can be designed.

Chapter II

The Structuring of Praxiology

One of the major purposes of this Project was to conceptualize a structure of industry as a basis for content in industrial arts. To accomplish this effectively, it was first necessary to investigate the nature of the major divisions of man's knowledge to establish the need for a study of man's total practices (praxiology). This was necessary because the need to study praxiology in our schools, in whole or in part, is ill-defined and lacking of general recognition as compared with the universal acceptance of the need to study fine arts and humanities, mathematics, and science. Having investigated in Chapter I the nature of and the need for praxiology, and having advanced a recommendation that youth study praxiological subject matter, there remain the problems of determining its subcategories and of delimiting and structuring the particular division of concern to this Project.

This Chapter deals with the problem of structuring praxiology, particularly as it relates to the problem of structuring industrial praxiology. To place this problem in its proper perspective relative to this Project, the status of industrial arts first is reviewed. Then, relevant terminological and conceptual problems are investigated. Finally, an adequate structure of praxiology, for the purposes of this Project, is presented.

A BRIEF REVIEW OF THE STATUS OF INDUSTRIAL ARTS

The need for the traditional school subjects is seldom questioned. This may be partially attributed to the development of a technically adequate terminology and the clear communication of the nature and scope of the knowledge to be studied in these subjects. Industrial arts, one of the newer school subjects, has gained popular acceptance and daily is studied by four million pupils in the United States. However, its value is still questioned, partially because of its comparative newness but also because even the specialists in the subject have difficulty in communicating because of the imprecise terms which are in common usage. These specialists are further handicapped, as are students, parents, and others, because their subject matter boundaries remain ill-defined.

The Need to Study Industrial Arts. Youth of even two generations ago could gain an understanding of the organization and the processes of early industry merely by exhibiting normal curiosity within their environment. The mysteries of the forge, food processing, textile manufacturing, and shoemaking largely were revealed. Even then, an organized study of industry was deemed by some to be as appropriate as nature study. In today's society, with the growing complexity of industry and with its operation either accidentally or purposefully removed from public view, it safely can be postulated that the school must provide an opportunity for students to study the industrial world, as well as the natural world.

An artificial wall often is placed between the study of the traditional school subjects and industry. Among others, C. P. Snow was concerned about this general point when he asked: "How many educated people know anything about productive industry, old-style or new?". He continued, "What is a machine-tool? I once asked a literary party; and they looked shifty. Unless one knows, industrial production is as mysterious as 'witch-doctoring'" (Snow, 1959, p. 32).

Snow combines pure and applied science under the term science and avoids use of the term technology. He states, "This (the scientific revolution) is the material basis of our lives: or more exactly, the social plasma of which we are a part. And we know almost nothing about it. I remarked earlier that highly educated members of the non-scientific culture couldn't cope with the simplest concepts of pure science: it is expected, but they would be even less happy with applied science" (Snow, 1959, p. 31).

Snow further identified a sub-conflict between members of the "scientific culture." He writes

> Pure scientists have by and large been dimwitted about engineers and applied science. They couldn't get interested. They wouldn't recognize that many of the problems were as intellectually exacting as pure problems, and that many of the solutions were as satisfying and beautiful. Their instinct--perhaps sharpened in this country (England) by the passion to find a new snobbism wherever possible, and to invent one if it doesn't exist--was to take it for granted that applied science was an occupation for second-rate minds (Snow, 1959, pp. 33-34).

Snow discusses four major groups whose members must be thoroughly grounded in pure and applied science if we are to cope with the problems posed by the scientific revolution. They are: (1) a class of pure scientists, (2) a high-class design and development group, (3) a natural-mechanical sciences group, and (4) a class of politicians and administrators. Most would agree that these groups have specialized educational needs. A smaller number acknowledge Snow's major point, that the educational needs of all citizens in contemporary, industrialized society demand educational programs which will provide an understanding of science (pure and applied) and the humanities, and which will provide the basis for a dialogue between the two (or three) cultures.

An effective industrial arts program can provide essential studies in a total educational program which attempts to cultivate an understanding of both the natural and the man-made world and also an understanding of the fine arts and humanities. Industrial arts, appropriately conceived and taught, can provide an understanding of how man manages industrial production, of the practices he employs to change resources into man-made goods, and of the knowledge of how to efficiently use and service these goods.

It should be made clear that industrial arts can provide an understanding of only part of man's total knowledge of practice. Educators generally need to devote attention to the larger question of what constitutes a broadly conceived program of study of praxiology.* The particular concern of this

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*Praxiology may be studied through interpretive themes which cut across all or most of the totality of the above fields (e.g., a comparative study of personnel practices in the praxiological fields such as business, education, industry, medicine, and so on). The critical need for this study of the world of work,on some basis, was pointed out forcefully by Harris: "Without a doubt the biggest task facing the American high school today is to make its curriculum meaningful to students. For hundreds of thousands of boys and girls this meaning must be found in subjects and curriculums related to the world of work" (Harris, 1963, p. 4).

Project is to conceptualize a basis for studying industrial praxiology, but it is recognized that this is but one piece of a puzzle which can be assembled completely only after all the subcategories of praxiology have been structured. With this done, the interrelationships can be studied for an understanding of all of man's practices.

The preceding problem in regard to the need for a comprehensive study of praxiology is not peculiar to this subcategory of man's total knowledge. Bellack states, "Although the four major areas of knowledge are generally recognized as important components of the curriculum, they are not currently used as the context or framework for curriculum building" (Bellack, 1964, p. 29). He proposes, ". . .we would do well to shift the context for curriculum planning from the individual disciplines, as is now the vogue, to the broad groupings of knowledge represented by the natural sciences, the social sciences, mathematics, and the humanities" (Bellack, 1964, pp. 29-30). To his listing we would add the praxiologies, though the immediate concern is with only industrial praxiology.

Industrial Arts Defined. In the search for appropriate technical studies, the antecedents of industrial arts progressed from drawing (taught in Boston in 1812 and made a mandatory school subject in Massachusetts in 1870), to manual training (practice with tools to train the hand, St. Louis Manual Training School, 1880), to manual arts (a greater emphasis on design and on complete projects rather than on unrelated practice exercises, Teachers College, New York City, 1893). At the turn of the present century, the term "industrial arts" was proposed to identify a more broadly conceived school subject (Richards, 1904).

A further development of the concept of the new industrial arts was presented by Bonser and Mossman in a work first published in 1923. Their teaching and writing revealed that the nascent period included at least a decade. They provided the field with its most widely quoted definition when they wrote

> The industrial arts are those occupations by which changes are made in the forms of materials to increase their values for human usage. As a subject for educative purposes, industrial arts is a study of the changes made by man in the forms of materials to increase their values, and of the problems of life related to these changes (Bonser and Mossman, 1925, p. 5).

Bonser and Mossman delimited "a study of the changes made by man" by excluding: (1) the study of extractive industries and agriculture because they "provide us with the natural materials themselves" and do not essentially change their form, and (2) the study of industries that provide place utility because, "changing the location of materials and products from place to place by transportation is not a matter of industrial art but of industrial exchange and commercial geography." They summarized the limits of industrial arts by stating, "To fix some reasonable limit in our use of the term, industrial arts, we include those occupations which have to do with the changes in the form of materials, and exclude those occupations having to do with procuring raw materials and transporting them and their products" (Bonser and Mossman, 1925, p. 4).

In regard to the "problems of life related to these changes," Bonser and Mossman wrote, "The social purpose in the study of the industrial workers and their work is realized in the measure that this study helps us to be intelligent and sympathetic in the regulation of the conditions of production so that employers, employees, and consumers shall all receive complete fairness and justice in the production or use of products" (Bonser and Mossman, 1925, p. 12).

The framework of the subject matter in this early view of industrial arts was provided by the suggested topics of: Foods, Clothing, Shelter, Utensils (dishes and pottery), Records (graphic processes and paper and book making), and Tools and Machines.

Unresolved Problems. For more than half a century industry has been viewed as the source of subject matter for industrial arts. Despite this, an adequate structure of the knowledge of industry, as an essential aid in the identification and organization of industrial arts subject matter, has not been conceived.* As a result, industrial arts generally has continued to be viewed as a study of selected skilled industrial crafts and trades or as a study of selected materials and of how they are processed. It has been generally recognized that studies organized on this basis will not provide an understanding of industry as one of the most dynamic social institutions in our culture, but the search continues for a viable alternative.

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*The implication here that Bonser and Mossman's content categories are rejected as a viable structure for a study of contemporary industry is intended. While their structure of subject matter may have been adequate to their time and for the elementary school, it does not provide for the present expanse of industrial practices or products. This should not detract from the proper recognition of this milestone in the further development of a comprehensive study of the knowledge of industrial practice. The means proposed by Bonser and Mossman are questioned, but their ends and their definition of the subject generally have become accepted.

There are two fundamental causes of the stagnation which has kept industrial arts from meeting adequately the challenge posed for it at the turn of the century: (1) a terminological problem and, directly related to the first, (2) a conceptual problem. These are analyzed in turn. Many other problem areas, such as the restraints posed by teacher certification, human resistance to change, and budgetary and physical limitations, are essentially secondary problems. They are not an immediate concern in this Project.

THE TERMINOLOGICAL PROBLEM

The persistent terminological problem must be resolved if there is to be adequate communication, one essential to organized progress. The loose usage of the terms "technology" and "industry" is at the root of the terminological problem.

Usage of the Term "Technology." Technology more or less has been equated with industry, both in industrial arts and generally in the literature on technology, as is revealed by a brief review of pertinent literature.

Olson (1963, p. 33) accepts Dewhurst's statement, "As technology consists of accumulated knowledges, techniques and skills, and their application in creating useful goods and services, the ultimate fruits of a country's technology are found in the standard of living its people are able to enjoy." Olson comments, "We shall let this interpretation of technology suffice as a guide to the study of the subject." He summarizes his interpretation of technology by stating, " . . . technology can be considered as the field of systematized knowledge derived from the study of the nature, the principles and practices, the products, the services, and the energies provided and employed by industry" (Olson, 1963, p. 55).

Walker states, "Since it would be impossible in less than a dozen volumes to look at the way technology influences all organizations, the emphasis (in this book) will be on industrial ones" (Walker, 1962, p. 1). He thereby indicates technology is more inclusive than industry but proceeds to equate technology with industry as follows:

> Technology includes both physical objects and the techniques associated with them. For instance, the technology of pottery making includes (1) the clay or other materials, (2) the potter's wheel or other machinery, and (3) all the skills and procedures that enter into making the product. Similarly, when (speaking) of the technology of an automobile assembly line, there is signified not only the moving conveyor and all other "hardware," but also the mass production methods devised by management and practiced by workers to assemble an automobile. In such a definition, scientific management and other kinds of engineering rules which impinge on people are included under the term "technology" (Walker, 1962, p. 2).

Thus, technology can be held to include finished "objects" and also materials, tools and machinery, skills, procedures, methods, and rules (information or knowledge) used in their production.

Ogburn espouses the thesis that technology has an essentially social character:

> We do not ordinarily think of technology as sociological. Rather we consider it as mechanical and belonging to the physical sciences. To the degree that technology is concerned with the making of physical objects, it lies in the realm of the physical sciences. The curricula of colleges of technology are largely devoted to the physical sciences and deal little with the biological or the social sciences. Producing the objects of technology is, then, not in the field of social science; but since the meaning of these technological objects lies in the field of the social sciences, it is strange that the social

> sciences have no concern with technology. They discuss behavior, motivations, relation of the individual to the group, and institutions such as the family, the church, and government as if they existed independently of a material culture. So, too, teachers in technological schools instruct their students in how to make this and construct that; and though these fabrications are to be used by society and have an effect upon social life, such matters appear to be of no concern to technologists. It is as if there were a great wall separating technology and sociology (Ogburn, 1957, p. 9).

If technology receives any mention in the school program it is generally inferred, by association, to be related to science; although the precise relationship is either not treated at all or it is represented as being an indistinct one. Also, little in the school program deals with the impact of technology on society as a whole or upon its basic institutions or upon the individual. In industrial arts, where one might expect to find the program keyed to providing an understanding of, at least, industrial technology and its implications for workers in industry, the program largely has been devoted to studies which basically are related to antiquated or obsolete material production technology.

Doubtless, a major difficulty in revising, expanding, and popularizing the study of technology is a lack of literature which deals with the subject as a macrocosm. A search of library indexes, bibliographies, and catalogs* produced a paucity of works on the nature or scope of technology according to a broadly conceived, encompassing structure. The dilemma is evident. On the one hand there is support for the study of technology, but a viable structure of the subject matter to be studied is not generally recognized, if it even has been proposed. The matter of structure is dealt with later as a part of the conceptualization problem.

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*See Appendix A for the sources searched.

A second difficulty in dealing with technology lies in the use of the term. The situation revealed by a review of the literature calls for a re-evaluation of the use of the term "technology." It means too many things to too many people. According to Webster (Webster's, 1961, p. 2348), one definition of technology states that it is "the totality of the means employed by a people to provide itself with objects of material culture." It is this definition which Dewhurst, Olson, Walker, and others use implicitly. Commonly, the focus is on "material culture" with only secondary concern for "the totality of the means employed." Thus, practices with humans often are overlooked even when they directly affect material production. That is to say, some fail to note that this definition provides for the inclusion within technology ("the totality of the means") of ways of motivating or safeguarding workers, for example, as means "to provide . . . objects of a material culture."

Little use is made of the additional definition by Webster which states that technology is "the science of the application of knowledge to practical purposes." This latter definition allows for technological practices with or without material ends. However, it also may be responsible for the conclusion that technology is merely "the application of knowledge" or, in common usage, applied science. This conclusion ignores the full definition with equal emphasis on "the science (systematized knowledge) of" which suggests knowledge of practical action (praxiology) which is more than the application of formal, descriptive, and prescriptive knowledge to practical ends.

Technology could be equated with praxiology only if the latter definition were used universally. In fact, technology commonly is used simply to include "hardware," while some use it to include the totality of the means to material ends (hardware and techniques or procedures with material ends), and others define it as a study either of all or of some part of man's practices (with either material or non-material ends). A term so loosely used communicates poorly.

An example may serve to clarify the confusion which can result from the present usage of the term "technology." The term "medical technology" may be used to refer to the x-ray machine, electrocardiograph, and similar hardware. It also may be used to include these items and their uses, as the processes or procedures of x-ray therapy or electrocardiography. In addition, what the surgeon does may be considered to be medical technology within the dictionary meaning of technology as "the science of the application of knowledge to practical purposes." However, doctors (and many other practitioners) generally do not wish to be called technologists, though they will readily admit to possessing and using knowledge of practice. Technology thus fails to serve in differentiating or classifying all of man's practices and subcategories of them. Clearly, there is a need for a more precise term, or for a more precise usage of technology as a descriptive name.

Usage of the Term "Industry." "Industry" is another term with many meanings. Robinson provides some insight into this problem.

> It had seemed from first glance that it would be possible for us to define an industry as a group of firms producing the same commodity for the same market. We must now recognize that to define it either by the commodity produced, or by the market for which it produces, is in many cases either impossible or at least unsatisfactory. In practice, all that we can do is to follow the example of those who are actually engaged in industries. Certain employers find that they have a common bond of interest with certain other employers, and come to regard themselves as composing an industry. It may be one of a common use of a single raw material, as in the iron and steel industry, the pottery industry, the cotton industry. It may be one of a common use of a given type of machinery, or of a given process of manufacture. Thus we may distinguish the textile industries; we may speak of brass founders or of steel rolling firms as having something in common which distinguishes them from other firms. Industries as such have no identity. They are simply a classification of firms which may for the moment be convenient. A change of technique and/or an organization may require a new classification and a new industry. In the past few decades we have added the aircraft and radio industries, the rayon, plastics and electronics industries to our list (Robinson, 1958, pp. 7-8).

The problem is further complicated by the term being used in connection with the service industries, i.e., the entertainment industry, the hotel industry, and others. Industry may be viewed as a term of convenience which leads to a morass that must be avoided if the goal is precise communication. Industry may be taken to mean "systematic work or labor" or a "branch of manufacture" or a societal institution, among other things. It must be that industry as a societal institution is the meaning intended whenever it is stated that industry is the source of content for industrial arts. Even if that is the intent, the relation of industry to other institutions of society must be clarified.

Cuber states that, "Sociologists generally regard the family, government, religion, the economic system, and education as the basic, important institutions of a society" (Cuber, 1951, p. 433). This leads to the conclusion that industry may be subsumed within the larger economic institution, and to know its nature as a social institution requires that it be placed in the broader context.

Some have equated industry with the economic institution. For example, the Standard Industrial Classification Manual authors state that their industrial classification system " . . . is intended to cover the entire field of economic activities . . ." (Bureau of the Budget, 1957, p. 1). The total system identifies industry as a whole, and each sub-element of the system, singly, or in ordered combinations, also is identified as an industry. That is to say, the total Classification classifies American industry. In addition, representative components of the system are: the manufacturing industry, the primary metal industry, the iron and steel foundry industry, and the grey iron foundry industry, with each succeeding example being of a subordinate order of classification. It is this lax usage which permits the term "industry" to mean all economic activity or, prefaced by an adjective, to mean some sub-element such as the professional football industry.

By returning to the early view of industrial arts previously presented, it can be noted that Bonser and Mossman did not equate industry with the economic institution. They omitted from their discussion capitalization and financial control and specifically excluded distribution and the genetic reproduction or extraction of materials. They equated industry with the production of material goods. These distinctions are not commonly made in the contemporary literature of industrial arts. Instead, the most universally attempted means to broaden traditional industrial arts offerings has been the teaching of a unit of study on mass production which includes consideration of capitalization, financial control, market analysis, production planning, and marketing.* Thus, it seems that some confusion exists as to the limits of the subject matter to be studied. It is viewed as anything from a study of one or more selected skilled trades or crafts to one or more selected industrial materials, techniques or processes; to a study of the entire economic institution.

It is apparent that part of the present confusion results from inadequate terminology. Toward the solution of this problem, new and/or revised terminology and meanings are proposed.

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*The booklet, "Teaching Industry Through Production," written by George R. Keane and published in 1959 by the American Industrial Arts Association is representative of recent writings which promote the introduction of a study of man's production into industrial arts. In this work, it is stated that, "The activity phase involves the selection of a committee (management) by the class (board of directors), to study, design, propose, and direct the manufacture and sales of a quality article." It is further stated that, "The production session is confined to one double or triple class period, if possible." Among fifteen suggested topics of study, apart from the double or triple period devoted to production, are: The mass product and what it means, Where the money comes from, Who takes the risk, Who buys the product, Advertising and sales, and Investment, costs and profit relationships. The balance of the topics deal more or less directly with supervision and production (Keane, 1959, pp. 1-3). This format is essentially one used by Junior Achievement for more than twenty years, usually outside the school setting, to provide interested youth with greater economic literacy.

Technology vice Praxiology. One meaning of technology is "the science of the application of knowledge to practical purposes." This single meaning can be communicated only if a substitute term is employed. Therefore, praxiology* is proposed as this new term whenever communication requirements make it essential that there be minimal provision for any other meaning. However, this poses a dilemma. On the one hand, praxiology has a precise meaning but, as most new terms, it serves poorly for general communications purposes. On the other hand, technology is in everyday usage and in the common vocabulary, but it has failed to gain universal acceptance as to its precise meaning. For the immediate future, it is assumed that the greatest progress and acceptance of a new school program in industrial arts can be achieved by working to popularize praxiology toward the ultimate goal of its general adoption but to restrict its present use to philosophical and professional discussions and literature. For general purposes, technology will be used in the Project, with the distinction that it will be given a single definition, one which equates it in meaning with praxiology.

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*Kaplan suggests the use of the term "methodology" in much this same sense. He states, "I mean by methodology the study--the description, the explanation, and the justification--of methods, and not the methods themselves" (Kaplan, 1964, p. 18). However, methodology has too many other meanings, particularly in education, for it to be used instead of praxiology. Kaplan also encountered difficulties with the term "technology." He states " . . . what is often called 'methodology' is concerned with techniques in this sense (if only the word 'technology' did not already have another meaning!)" (Kaplan, 1964, p. 19).

Praxiology (Technology) Defined. Praxiology (Technology) is the product of the organized, disciplined study of the practices of man. It has to do with all of the practices which ultimately affect individual and social human behavior. Praxiological (Technological) knowledge is not simply that formal, descriptive, and prescriptive knowledge which relates to the solution of practical problems; it is not practice *per se*. Praxiology (Technology) is a distinct, developing body of knowledge (principles) which is being tested in practice and is or is likely to be codified. There are gradations in the extent to which praxiological (technological) knowledge relates to "pure" or "theoretical" knowledge. It includes knowledge which results from the modification of "pure" theoretical knowledge, in practice, to formulate theory of practice. It also includes other practical knowledge which is not rooted in formal theory, or, if it is, is so tangentially or distantly related as to profit little from the relationship. It is the theory of practice which enables the surgeon to repair, the architect to design, the farmer to produce, and the technician to adjust. To deny the existence of praxiological (technological) knowledge is to suggest that the physiologist can perform surgical practice, or that the physicist can repair television receivers.

Conceptualizing and organizing a study of the totality of praxiology (technology) is not the concern of this Project, though it is work that educators should undertake. This Project is vitally concerned with conceptualizing a structure for that division of praxiology (technology) which is the appropriate concern of industrial arts; that is, industrial praxiology (technology).

Economic Institution Defined. The economic institution is one of the fundamental institutions of human society. Its function is to satisfy man's wants for economic goods. The economic institution is classified by the Standard Industrial Classification Manual to include:

Division A.	Agriculture, forestry and fisheries;
Division B.	Mining;
Division C.	Contract construction;
Division D.	Manufacturing;
Division E.	Transportation, communication, electric, gas, and sanitary service;
Division F.	Wholesale and retail trade;
Division G.	Finance, insurance, and real estate;
Division H.	Services;
Division I.	Government;
Division J.	Nonclassifiable establishments. (Bureau of the Budget, 1957, pp. v-vii).

Industry Defined. Industry is that subcategory of the economic institution which substantially changes the form of materials in response to man's wants for goods. In the process, it generates knowledge of how to efficiently produce, use, and service industrial material goods. Industry essentially includes those establishments included under S.I.C. Divisions "C" and "D"; that is, contract construction and manufacturing, respectively. Therefore, industry does not include transportation, communication, utilities, banking, and marketing, for example.

Industry produces the material goods used in transportation, banking, communication, and in other economic activities, but non-industrial establishments operate and control these goods to provide non-material production. These latter establishments, therefore, are properly classified as wholesale and retail trade, transportation, finance, or some other sub-element of the economic institution. Only construction and manufacturing are engaged in the forming of materials to satisfy man's wants for goods, and they are the components of industry.

While agriculture, forestry, fisheries, and mining produce material goods, they do not essentially change their form. These genetic and extractive "industries" provide industry (construction and manufacturing) with one portion of the input (raw materials) to their production systems.

The entire S.I.C. system--and particularly Division H, Services--contains an incongruity in relation to an adequate definition of industry. Some industrial services (services to industrial material goods) are categorized within Division H, and others are hidden within other Divisions. For example, airport and aircraft maintenance are reported under Transportation in Division E if the services are provided by the air carriers; if an independent service agency would provide the same services, they would be reported under Services in Division H. For purposes of collecting economic data about industry, all these services could be considered to be part of industry, as some similar services are.

Industrial establishments sometimes provide services within the establishment, and these are considered to be a part of industry. Some identical services are provided by independent groups and individuals who are described in S.I.C. Division H. Services, or in one of the other Divisions. Still other of these services are not accounted for because they are provided to industrial goods by the owners and operators of them. Combined data on these services are not provided by standard sources, leaving the total activity in servicing industrial goods as an elusive quantity.

Attempts to dichotomize industry in terms of goods producing and goods servicing can lead to an ultimate conclusion that the total population is part of industry because all do render some services to their apparel, homes, and other goods. In the study of industry, it would be more efficient to focus on the industry-produced knowledge of how to operate and service industrial goods, rather than upon when, where, why, and/or by whom it is used.

Industrial Praxiology (Industrial Technology) Defined. Industrial praxiology (technology) is that subcategory of praxiological (technological) knowledge which is derived from the study of principles of industrial practices. In such practices there are those which have to do with industrial management and those which have to do with industrial production. Some of these practices primarily affect the workers, as is the case with work incentives. Such practices also may affect directly or indirectly the material being produced. Other practices primarily affect materials, as in the case of nailing or adjusting. Such practices also may directly affect the worker and are instrumental to the modification of the behavior of the consumer. Collectively the knowledge of these practices may be called industrial praxiology (technology), and, ultimately, they all affect human behavior. The knowledge of practices which primarily affect the behavior of industrial workers is a part of industrial arts subject matter, as well as part of the social sciences. The effects of industrial practices on society outside of industry are primarily a part of the subject matter of the social sciences.

The existence of interfaces between subcategories of knowledge--for example, the common ground between industrial technology and psychology in industrial psychology--are ubiquitous in systems for classifying knowledge into sub-elements. These areas of common concern are important to an understanding of the respective sub-elements. Thus, a knowledge of industrial medicine may reinforce and extend knowledge of both industrial practice and medical practice. However, in a study of industry, interfaces with other sub-elements of knowledge necessarily would be viewed primarily as they relate to industrial practice.

Industrial Arts Redefined. Industrial arts is an organized study of the knowledge of practice within that subcategory of the economic institution of society which is known as industry. Industrial arts logically cannot be equated with industrial praxiology (technology). Industrial praxiology (technology) is a body of knowledge which provides subject matter for the studies of the industrial-vocational student, the industrial technician, and the industrial engineer, as well as the industrial arts student, the college student of industrial psychology, and many others. Thus, industrial praxiology (technology) may be studied for many purposes and at various levels. Knowledge of industrial practices may be studied in industrial arts for the purpose of helping pupils gain an understanding of how they affect materials and humans in industry. Understanding, as used in this definition, includes both a knowledge of practices and the ability to apply the practices themselves. Industrial arts may be studied in pre-school, school, college and university, adult, and specialized studies. Industrial practices which affect materials can be studied independently as can industrial practices which affect the men involved in material production, but a complete understanding requires the study of both of these kinds of practices and their interrelationships.

THE CONCEPTUAL PROBLEM

Reinforced with adequate terminology, the conceptual problem can be attacked. As indicated earlier, a clear conceptualization of the interrelationships between man's knowledge, praxiology (technology), and industrial praxiology (technology) are essential to the ultimate development of a program of studies which can provide an understanding of industry. The relationship of praxiology to man's knowledge was presented in Chapter I. The relationships between praxiology (technology) and industry are analyzed and conceptualized in the balance of this Chapter.

Praxiology heretofore has not been structured. Thus, the only developed literature which may be considered to be related to praxiology is a limited number of works on technology as it may be equated with praxiology. While few authors or agencies have interpreted technology as "the science of the application of knowledge to practical purposes," it is important to investigate the extent to which writers in technology have attempted to develop a structure of this scope.

The search for an adequate structure of praxiology (technology) included a review of histories of technology, occupational classification systems, product classification systems, establishment classification, patent office classifications, technological museums, reference works, the work of curriculum theorists, and programs in institutions of higher learning. Each of these actual or implied structures is analyzed and evaluated in turn.

Histories of Technology. Historians of technology may be presumed to have some generalized structure for the treatment of their subject. Figure I provides data which strongly suggest that there is no consensus among these writers, as indicated by their works, on what major elements make up the field of study. Mainly the subject is viewed by them to be mechanical technology and only rarely do they view the field as including health or medical technology, food technology, or other possible divisions of technology besides those related to mechanical and civil engineering.

In Figure I, a comparison is made of subject matter covered in histories of technology with the major divisions of The Standard Industrial Classification Manual (Bureau of the Budget, 1957). Subject matter headings which resisted classification were placed in an added category, Unclassified. Some topics or parts of topics relate to more than one category. In these instances, the relationship is indicated by parentheses around the term with a superscript indicating the number of the other division or divisions where the indicated topic also may be classified.

Most of the topics in histories of technology relate to man's economic activity. In Figure I there are relatively few topics in the unclassified category.

The categories listed under Ferguson in Figure I are not taken from a history of technology, as are the ones listed under other authors. The categories in this column are the classification headings in a bibliography in the history of technology and are especially pertinent to the analysis of classification systems used by historians of technology. In this case, Ferguson suggests a generalized classification system appropriate to the classification of all works in the field. The works reviewed in Figure I are identified only by author and title. The complete identification can be found in the References.

Occupational Classifications. Another possible structure of technology could result from classifying what men do. That is, by studying what technological workers do, it may be hypothesized that a systematic structure of technology could result. Much has been done in classifying what men do in producing our goods and services. Gulick states in his classic essay that every individual worker can be characterized by:

> The major purpose he is serving, such as furnishing water, controlling crime, or conducting education;
>
> The process he is using, such as engineering, medicine, carpentry, stenography, statistics, accounting;

Source Division	Bronowski, J., Technology: Man Remakes His World, (London 1963)	Derry and Williams, A Short History of Technology. (Oxford 1961)	Ferguson, Eugene S., "Contributions to Bibliography in the History of Technology (Part 1)," Technology and Culture. Winter, 1962, pp. 73-84.	Forbes, 1958) (e
1. Agriculture, forestry and fisheries	8 Food and Agriculture	2 The Production of Food 24 Agriculture and Food	13 Agriculture and (Food)^6 Technology	
2. Mining	4 The Riches of the Earth	4 The extraction and (Working of Metals)^4 16 Coal and the Metals		
3. Construction	10 Building: Materials and Methods	5 Building Construction 14 Building Construction: Requirements for Urban Communities 15 Building Construction: Requirements for Transport	7 Civil Engineering Buildings, bridges and tunnels, (Water supply and sewerage)^5; Urban engineering; Surveying, instruments, and maps.	(2) (Irri (3) The (3) Aqu (4) The (4) Aqu (7) Ca (9) The (9) Asp (9) Bri
4. Manufacturing	5 Chemical Technology 6 Metals and Their Uses 7 Ceramics and Glass 9 Textiles and Leather	3 Production for Domestic Needs 9 The Beginnings of the Chemical Industry 12 Machine-Tools and Their Products 17 New Materials: Coal-Gas, (Petroleum)^2 and Rubber 18 The Rise of the Modern Chemical Industry 19 Textiles 20 Pottery and Glass 23 Printing, Photography, and the Cinema	10 Materials and Processes Metals: (mining)^2, processing, metallurgy; chemical industries; ceramics, glass, cement; (oil and gas)^2; paper and printing; textiles; plastics; (lumber)^1; (coal)^2. 11 Mechanical and Electro-Mechanical Technology Tools, machines, instruments, timekeepers, calculating machines and computers; automatic control; typewriters; sewing machines etc.; mechanical power transmission; weights and measures 14 Industrial Organization Management Technique, mass production techniques	(2) Spi (2) Pot (2) Wo (2) Me (3) Gl (3) (Th (4) Alc (6) Ri (6) Ca (6) Ch (6) Pa (7) Me (7) Me (8) Ste Ent (10) Ri (10) Syn (10) Tra Rub
5. Transportation, Communication, electric, gas and Sanitary services	3 Power: Energy at Work 11 Land Transport 12 Water Transport 13 Air Transport 15 Communications and Control	6 Transport 7 Communication and Record 8 Early Sources of Power 11 The Steam Engine 13 Modern Transport 21 The Internal Combustion Engine 22 The Electrical Industry	8 Transportation (ships)^3; naviation and charting; (canals)^3 and boats; (roads)^3 and (vehicles)^4; (aircraft)^4 and (space-craft)^4 9 Energy Conversion Hydralic engineering internal-combustion engines; steam engines; steam electric central stations; electrical power transmission; lighting; heating and ventilating; refrigeration; nuclear, solar, and direct conversion power plants 12 Communication and Records (except printing) Telegraph, telephone, radio, phonography; photography	(2) The (2) Co (3) (Mo (4) Co (5) Pov (6) Ho (6) Sai (7) The (7) The (7) The (9) Ste (9) Bu (9) The (9) The (9) The (10) Ge Ele (10) The (10) Ra (10) The
6. Wholesale and Retail Trade				
7. Finance, Insurance and Real Estate			5 Economic, Business, (Political)^9, and Social History; (Travels and Description)^5	
8. Services (including agricultural services)				(7) I (10) T
9. Government	14 Military Technology		15 Military Technology	(4) W
10. Unclassified	1 Reshaping Our World 2 Measurement: Basic Techniques 16 Technology: A summing up	1 General Historical Survey 10 Historical Survey (1750-1900) 16 Epilogue: Technological and General History	1 General and Collected Works 2 Documentation 3 Biography 4 Technical Societies, Technical Education (including Museums and Exhibitions) 6 General Relationships Between Technology and Culture	(1) D (1) D (2) T (2) T (3) S (4) M (4) G (4) T (5) A (6) M (6) T (7) T (7) L (7) T

* The chapters in the works of Forbes and Klemm are arranged by periods. In order to classify their material, subject headings within these chapters were used. The chapter from which a particular subject heading was drawn is indicated by the chapter number in parentheses. Ferguson's bibliography is arranged by sections. Chapter and subject headings found in the chart in parentheses with a numerical designation 1 to 10 indicates where this material also may be appropriately classified. Chapter and subject headings were not subdivided in the chart in order to maintain the unity of the organization.

Figure I

CHAPTER HEADINGS* IN HISTORIES OF TECHNOLOGY

	Forbes, R. J., Man the Maker. (New York 1958) (arranged by periods and topic)	Klemm, Friedrich, A History of Western Technology. (New York 1959) (arranged by period and topic)	Singer, et al., A History of Technology, (Vol. I) (Oxford 1954)	Singer, et al., A History of Technology. (Vol. II) (700 B.C. to A.D. 1500) (Oxford 1956)	Singer (Vol.
			8 Foraging, Hunting, and Fishing 13 Domestication of Animals 14 Cultivation of Plants 19 (Water Supply)[5], Irrigation, & Agric.	3 (Agricultural Implements)[4] 4 (Food and Drink)[6/4]	1 (Fo
		(1) Roman Mining (3) German Mining and (Handicraft)[4]	20 Mining and Quarrying	1 Mining and Quarrying to the Seventeenth Century	3 Co
	(2) (Irrigation and Its Effects)[1] (3) The Earliest Architects (3) Aqueducts and Canals (4) The Roman Road (4) Aqueducts and Bridges (7) Canal and Drainage Projects (9) The New Science of Road Building (9) Asphalt and Concrete Roads (9) Bridges and Canals	(1) The Architect	12 Building in Wattle, Wood, and Turf 17 Building in Brick and Stone	12 Building Construction 16 Shipbuilding	10 B 11 T to 12 L 16 B 17 C 1 18 S 19 (C to 20 (C 14
g s	(2) Spinning and Weaving (2) Pottery (2) Working Stone (2) Metallurgy (3) Glass and Textiles (3) (The Coming of Iron)[2] (4) Alchemy and Metallurgy (6) Rise of the Textile Industry (6) Cast Iron and (New Arms)[9] (6) Chemical Technology (6) Paper and Printing (7) Mechanics and Industry (7) Metallurgy and Chemical Technology (8) Steam Comes of Age (1750-1830) Entire Unit (10) Rise of the Steel Industry (10) Synthetic Raw Materials (10) Transforming Natural Products: Rubber and Oil	(2) Urban Industry (3) Iron Foundries of the Early Renaissance (5) Master Craftsmen and Millwrights (6) (The Widening Use of the Steam Engine)[5] (6) The Factory System (7) Large-scale Synthetic Chemistry (7) Automation	6 Working Stone, Bone, and Wood 11 Chemical, Culinary, and Cosmetic Arts 15 Pottery 16 Textiles, Basketry, and Mats (and Rope-making) 18 Differentiation of Non-Metallic Tools 21 Extracting, Smelting, and Alloying 22 Metal Implements and Weapons 23 Fine Metal Work 24 Fine Ivory Work 25 Fine Wood Work	2 Metallurgy 5 Leather 6 Spinning and Weaving 7 Furniture: To the End of the Roman Empire/Post Roman 8 Ceramics: From c. 700 B.C. to the Fall of the Roman Empire/ Medieval 9 Glass and Glazes 10 Pre-Scientific Industrial Chemistry 11 (The Medieval Artisan)[3] 13 Fine Metal Work 18 Machines 21 Alchemical Equipment	2 (5 T 6 (F 1 7 S 8 F 9 G 13 M 15 Pr 22 Pr 23 Th fr 24 M 25 In
es; n;	(2) The Wheel (2) Communication (3) (Money)[7] and Communication (4) Communications and The Empire (5) Power Sources of the Arabs (6) Horse, Water Wheel, and Windmill (6) Sailing the Ocean (7) The Power Sources of the New Europe (7) The Road Regains its Importance (7) The Ship (9) Steam Power and Land Traffic (9) Bus, Street Car, and Bicycle (9) The Development of the Automobile (9) The New Engines Come to the Ship (9) The Conquest of the Air (10) Generating and Transmitting Electricity (10) The Applications of Electricity (10) Radio and Television (10) The Steam Turbine and Power Stations	(7) Electro-technology (7) Flight and Radio (7) Atomic Energy	7 (Graphic and Plastic Arts)[4] 10 Fire-making, Fuel, and Lighting 26 Land Transport Without Wheels (Roads and Bridges)[3] 27 (Wheeled Vehicles)[4] 28 (Boats and Ships)[4]	14 (Roads)[3] and Land Travel, with a section on harbors, docks and Lighthouses 15 Vehicles and Harness 17 Power 19 Hydraulic Engineering and Sanitation	4 Wi
		(5) (Trade)[6] and Finance (5) The Liberal Economy			
	(7) Improvement in (City Services)[5] (10) The Canning and Shipping of Food				
	(4) War Engines	(1) Making Artillery (2) Military Technology of the Late Middle Ages		20 Military Technology	14
	(1) Discoveries and Inventions (1) Diffusion of Inventions (2) The Old Stone Age (2) The New Stone Age (3) Science and the Craftsman (4) Machinery in Classical Society (4) Greek Engineering (4) The Roman Engineer (5) Arab Technology (6) Medieval Science (6) The Medieval Engineer (7) The Birth of the New Science (7) Leonardo the Pioneer (7) Technology and The New Science	About one-half the topics in the table of contents relate solely to periods, rather than topics, and are therefore neither listed here nor above.	1 Skills as a Human Possession 2 Early Forms of Society 3 Discovery, Invention, and Diffusion 4 Speech and Language 5 Primitive Time-Reckoning 9 Rotary Motions 29 Recording and Writing 30 Measures and Weights 31 Ancient Mathematics and Astronomy		21 T

Singer, et al., A History of Technology. (Vol. II) (700 B.C. to A.D. 1500) (Oxford 1956)	Singer, et al., A History of Technology. (Vol. III) (c. 1500 - c. 1750)	Singer, et al., A History of Technology. (Vol. IV) (c. 1750 - c. 1850) (Oxford 1958)	Singer, et al., A History of Technology. (Vol. V) (c. 1850 - c. 1900) (Oxford 1958)
3 (Agricultural Implements)[4] 4 (Food and Drink)[6/4]	1 (Food and Drink)[6/4]	1 I. Agriculture: (Farm Implements)[4] II. Agriculture: Techniques of Farming 2 Fish Preservation	1 Growth of Food Production
1 Mining and Quarrying to the Seventeenth Century	3 Coal Mining and Utilization	3 Metal and Coal Mining 1750-1815	4 New Extraction Process for Metals 5 Petroleum
12 Building Construction 16 Shipbuilding	10 Building Construction 11 Town-Planning from the Ancient World to the Renaissance 12 Land Drainage and Reclamation Bridges 16 Bridges 17 Canals and River Navigations before 1750 18 Ships and Shipbuilding 19 (Cartography, survey, and Navigation to 1400)[5] 20 (Cartography, survey, and Navigation 1400-1750)[5]	15 Building and Civil Engineering Construction 16 I. (Sanitary Engineering: Water-Supply)[5], II. (Sanitary Engineering: Sanitation)[5] 17 Road to c. 1900 18 I. Canals: Inland Waterways outside Britain II. Canals: Inland Waterways of the British Isles 19 Ship Building 21 Dredging	16 Ship Building 20 Building Materials and Techniques 21 Bridges and Tunnels
2 Metallurgy 5 Leather 6 Spinning and Weaving 7 Furniture: To the End of the Roman Empire/Post Roman 8 Ceramics: From c. 700 B.C. to the Fall of the Roman Empire/Medieval 9 Glass and Glazes 10 Pre-Scientific Industrial Chemistry 11 (The Medieval Artisan)[3] 13 Fine Metal Work 18 Machines 21 Alchemical Equipment	2 (Metallurgy and Assaying)[2] 5 Tradesmen's Tools c. 1400-1850 6 (Farm tools)[1], (Vehicles)[5], and Harness 1500-1900 7 Spinning and Weaving 8 Figured Fabrics 9 Glass 13 Machines and Mechanisms 15 Printing 22 Precision Instruments to 1500 23 The Manufacture of Scientific Instruments from c. 1500 to c. 1700 24 Mechanical Timekeepers 25 Invention in the Chemical Industries	4 I. (Extraction)[2] and Production of Metals: Iron and Steel II. (Extraction)[2] and Production of Metals: Non-Ferrous 8 I. The Chemical Industry: Developments in Chemical Theory and Practice II. The Chemical Industry: Interaction with the Industrial Revolution 10 I. The Textile Industry: Machinery for Cotton, Flax, and Wool II. The Textile Industry: Silk Production and Manufacture 11 Ceramics from the 15th Century to the Rise of the Staffordshire Potteries 12 Glass 13 Precision Mechanics 14 Machine Tools	3 The Steel Industry 11 Heavy Chemicals 12 Dyestuffs in the 19th Century 13 Explosives 14 Fine Chemicals 24 I. The Textile Industry: Woven Fabrics II. The Textile Industry: Hosiery and Lace 25 The Working of Metals 26 Machine-tools 27 Ceramics 28 Glass Technology 29 Printing and Related Trades 30 I. The Photographic Arts: Photography II. The Photographic Arts: Cinematography 31 Production and Utilization of Rubber
14 (Roads)[3] and Land Travel, with a section on harbors, docks and Lighthouses 15 Vehicles and Harness 17 Power 19 Hydraulic Engineering and Sanitation	4 Windmills	5 Power to 1850 6 The Steam Engine to 1830 7 Watermills c. 1500 - c. 1850 9 Gas for Light and Heat 20 Cartography 22 Telegraphy	6 The Stationary Steam Engine 1830-1900 7 The Marine Steam Engine 8 Internal Combustion Engines 9 The Generation of Electricity 10 The Distribution and Utilization of Electricity 15 The Development of Railway Engineering 17 Aeronautics 18 Mechanical Road-Vehicles 19 Cartography and Aids to Navigation 22 Hydraulic Engineering 23 Water-Supply
			2 Management and (Preservation of Food)[4]
20 Military Technology	14 Military Technology		
	21 The Calendar	23 The Beginning of the Change from Craft Mystery to Science as a Basis for Technology	32 Education for an Age of Technology 33 Technology and Industrial Organization 34 Technology and Its Social Consequences

> The persons or things dealt with or served, such as immigrants, veterans, Indians, forests, mines, parks, orphans, farmers, automobiles, or the poor;
>
> The place where he renders his services, such as Hawaii, Boston, Washington, the Dust Bowl, Alabama, or Central High School (Gulick, 1937, p. 15).

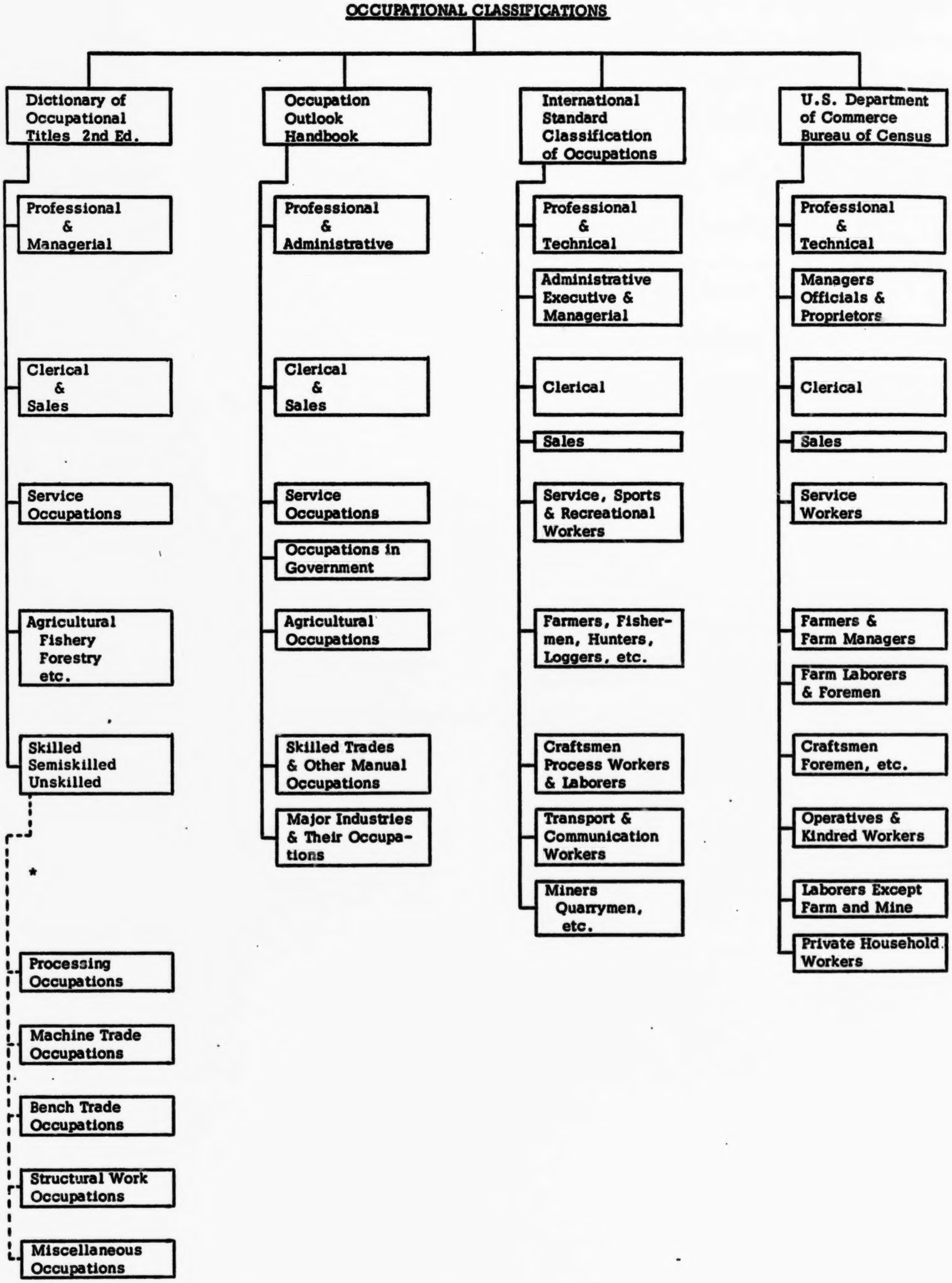
It is conceivable that these four headings could be used as major divisions of technology and the occupational classification systems presented in Figure II could provide an organized approach to the total content in this field of study.

Despite the orderly detail with which occupations have been classified, with the Dictionary of Occupational Titles providing over 35,000 job titles, existing classification systems indicate what men do but not how or why they do it. In addition, there is little to suggest that one who knows all the thousands of occupations in detail could synthesize them and provide an intelligible description of technology; and this avoids the question of whether anyone could, even with a lifetime of study, know all existing occupations. If one cannot study them all, there must be some criteria for selecting or sampling representative ones, which only implies the need for some other structure as a basis for studying technology.

Product Classifications. Man's products may be classified to provide a system which may be used as a basis for the study of technology. Figure III presents major classifications which are used to report national and international production. Additional classification systems are reported in Appendices B, C, D, and E. It can be noted that there is great similarity among these systems.

Figure II

OCCUPATIONAL CLASSIFICATIONS


Dictionary of Occupational Titles 2nd Ed.
Professional & Managerial
Clerical & Sales
Service Occupations
Agricultural Fishery Forestry etc.
Skilled Semiskilled Unskilled
*
Processing Occupations
Machine Trade Occupations
Bench Trade Occupations
Structural Work Occupations
Miscellaneous Occupations
Occupation Outlook Handbook
Professional & Administrative
Clerical & Sales
Service Occupations
Occupations in Government
Agricultural Occupations
Skilled Trades & Other Manual Occupations
Major Industries & Their Occupations
International Standard Classification of Occupations
Professional & Technical
Administrative Executive & Managerial
Clerical
Sales
Service, Sports & Recreational Workers
Farmers, Fishermen, Hunters, Loggers, etc.
Craftsmen Process Workers & Laborers
Transport & Communication Workers
Miners Quarrymen, etc.
U.S. Department of Commerce Bureau of Census
Professional & Technical
Managers Officials & Proprietors
Clerical
Sales
Service Workers
Farmers & Farm Managers
Farm Laborers & Foremen
Craftsmen Foremen, etc.
Operatives & Kindred Workers
Laborers Except Farm and Mine
Private Household Workers

* 3rd Edition D.O.T.

Figure III

GROSS NATIONAL PRODUCT (by source)

U.S. Deskbook[1]	Economic Almanac[2]	Statistical Abstract[3]	National Accounts[4]	Stat. of Nat. Acc.[5]
Agriculture, forestry, fisheries	Agriculture, forestry, fisheries	Agriculture, forestry, fisheries	Agriculture, forestry, fisheries	Agriculture, forestry, fisheries
Mining	Mining	Mining	Mining and Quarrying	Mining and Quarrying
Contract Construction	Contract Construction	Contract Construction	Contract Construction	Contract Construction
Manufacturing	Manufacturing	Manufacturing	Manufacturing	Manufacturing
Wholesale & Retail Trade	Wholesale & Retail Trade	Wholesale & Retail Trade	Wholesale & Retail Trade	Wholesale & Retail Trade
Finance, insurance & Real Estate	Finance, insurance & Real Estate	Finance, insurance & Real Estate	Banking, insurance & Real Estate	Banking, insurance & Real Estate
Transportation	Transportation	Transportation	Transportation, storage & communications	Transportation & communication
Communications & Public Utilities	Communications	Communications		
	Public Utilities	Public Utilities	Electricity, gas & water	Electricity, gas & water
Services	Services	Services	Services	Health and Educational Services
				Miscellaneous Services
Government	Government	Government	Public Administration & defense	Public Administration & defense
			Ownership of Dwellings	Ownership of Dwellings
Rest of World	Rest of World	Rest of World		

[1] U.S. Deskbook of Facts and Statistics 1964-65
Fairfield Publishers
Connecticut

[2] The Economic Almanac 1964
National Industrial Conference Board
New York

[3] Statistical Abstract of the United States 1964
U.S. Department of Commerce

[4] Yearbook of National Accounts, Statistics
United Nations
New York, 1964

[5] Statistics of National Accounts for Economic Co-operation and Development
Paris
1964

By Major Type of Product[1]

1. Goods output
2. Services
3. Construction

By Legal Form of Organization[1]

1. Business
2. General Government
3. Households & Institutions
4. Rest of World

General Breakdown[5]

1. Agriculture, forestry, fishing
2. Industry
3. Trade and Transportation
4. Other Services

These classifications (or a synthesis of them) possess nearly the same shortcomings, as a basis for studying technology, as do occupational classifications. Product classification systems are concerned with what man makes but not with how or why he makes it.

Establishment Classifications. The system reported in the Standard Industrial Classification Manual (Bureau of the Budget, 1957, pp. 1-433) classifies all economic activity by means of establishments rather than legal entities or companies. Thus, it is concerned with economic activity of particular types at individual locations. This system does not provide a structure of technology because it is by design restricted largely to the economic institution, for which it provides an adequate classification system. In addition, it does not provide an adequate classification system for industrial praxiology, because it fails to illuminate the human role in productivity. While it identifies the types of establishments which are conducting certain activities, it does not reveal how they are organized or how they operate.

This system exemplifies the problems encountered in attempting to establish a complete but discrete structure. While government and education each are basic social institutions, both participate in economic activities. Thus, the S.I.C. system has a division titled "government" and a lesser group titled "educational services." The system also encounters difficulty when it attempts to classify establishments which do not fit the categories. That is, it must arbitrarily classify establishments according to their principal product or service or by the activity in which the greatest number of employees work. Many establishments make varied products or render varied services, thereby causing one classification to represent the character of the establishment inadequately.

Patent Office Classifications. The United States Patent Office has evolved a classification system to enable interested parties to identify individual or groups or classes of patents. This system is reported in a loose-leaf volume which lists 346 main classes which are subdivided into 57,000 subclasses. This is the official classification system for all U. S. patents (Manual of Classification, 1960, p. 542). The 346 main classes, as abstracted from a 1961 publication, are listed alphabetically in Appendix F (Forman, 1961, pp. XIX-XXII). This classification system is under constant revision; and a study is underway to determine the desirability of changing over to an international classification system, thereby avoiding the present need to reclassify patents from other national systems in order to integrate them into the U. S. system.

This system should be an invaluable resource in the detailing of industrial products and processes with materials; but its first order of classifications, 346 in number, must be restructured into higher order classes for instructional purposes. It is not efficient to search 346 classes as a point of departure, in moving toward greater specificity. In addition, the patent system is restricted to practices which affect materials. It provides no assistance in identifying or classifying practices which affect the humans who are engaged in material production.

Technological Museums. Technological museums are concerned with classifying and displaying technology. In Figure IV are presented the major exhibits in the History and Technology Department, one of the four departments of the Smithsonian Institution: Armed Forces History, Civil History, History and Technology, and Arts and Manufactures. Figure V lists the displays of the Museum of Science and Industry, Chicago. It is not organized according to departments.

The technological museums, and the ones above are representative of the largest and best known, conceive of technology as including more than mechanical hardware. However, because these institutions are concerned with effective usage of their limited spaces (limited as to the demands of the task but vast in cubic footage) they are forced to use criteria for the selection of displays which are not ones which would make their classifications orderly or comprehensive bases for the study of technology. For example, criteria for museum display selection may include current interest. This is an appropriate concern for drawing and pleasing an audience but is not a fundamental consideration in structuring a body of knowledge.

Reference Works. An obvious source of careful thought regarding the ordering, categorizing, or structuring of technology should be major reference sets and encyclopedias. An exhaustive search of such sources failed to reveal any such treatment of the subject. Representative of such works are the: (1) 15 volume set of the Encyclopedia of Science and Technology, (2) 24 volume set of the Encyclopaedia Britannica, (3) 30 volume set of

Figure IV

SMITHSONIAN INSTITUTION,
UNITED STATES NATIONAL MUSEUM, WASHINGTON
The Fifty-one Exhibits
of the Museum of History and Technology
as of January 23, 1964

1. Farm Machinery
2. Lumbering & Wood Industries
3. Watercraft
4. Road Vehicles
5. Railroads
6. Bridges & Tunnels
7. Power Machinery
8. Electricity
9. Tools
10. Light Machinery
11. Physics
12. Nuclear Energy
13. Chemistry
14. Textile Machinery & Fibers
15. Textile Processing
16. Medicine & Dentistry
17. Pharmacy
18. Health
19. Manufacturers
20. Petroleum
21. Coal
22. Iron & Steel
23. Special Exhibits: History & Technology
24. Flag Hall
25. Discovery of America
26. Colonization in North America
27. National Growth
28. Industrial Growth
29. Age of Science
30. 17th Century Furnishings
31. 18th & 19th Century Furnishings
32. Gowns of the First Ladies
33. Historic Americans
34. American Dress

35-37. History of the Armed Forces

38. Decorations & Insignia
39. Ordnance and the *Philadelphia*
40. Underwater History
41. Photography
42. Motion Picture Photography
43. Graphic Arts: Hand Processes
44. Graphic Arts: Photomechanical Processes
45. Special Exhibits of Prints & Photographs
46. Numismatics
47. Philately
48. Ceramics
49. Glass
50. Musical Instruments
51. Changing Exhibits

Figure V

EXHIBITS OF THE MUSEUM OF SCIENCE AND INDUSTRY, CHICAGO*

(1964)

1. Hardwoods
2. Wheels A'Rolling
3. Graphic Arts
4. Newspaper
5. Seapower
6. Submarine U 505
7. Pioneer Trains
8. Nuclear Science
9. Engineering Construction
10. Cars of Yesteryear
11. Yesterday's Firefighters
12. Railroads
13. Fairy Castle
14. Microworld
15. Coal Mine
16. Flame Gas
17. Dolls
18. Glass
19. Phosphorous
20. Abrasives
21. Ship Models
22. Brussels Fair Scientific Exhibits
23. Air Transportation
24. Antique Autos
25. Food Preparation
26. TV Station WTTV
27. Hall of Elements
28. Food for Life
29. Tale of a Tub
30. Rubber
31. Motorama
32. Yesterday's Main Street
33. Petroleum
34. Steel
35. The Farm
36. Time
37. World of Numbers
38. Telephone
39. "Chemical Man"
40. Sound and Music
41. Electric Power
42. Electric Theater
43. Geometry
44. Medical Science
45. Space Age Exhibits
46. Airplanes
47. Tools
48. The Home
49. Water Resources
50. Library
51. Century of Progress
52. Blacksmith Shop
53. Steel
54. Magnetism
55. Optics
56. Electricity
57. Light
58. Television
59. Magic of Motion

*This sequence of exhibits resulted from a listing of the titles shown on a floor plan.

the Encyclopedia Americana, and (4) the 20 volume set of the World Book Encyclopedia.

The Encyclopedia of Science and Technology, under the entry "technology" relates that technology is:

> Systematic knowledge and action, usually of industrial processes but applicable to any recurrent activity. Technology is closely related to science and engineering. Science deals with man's understanding of the real world about him--the inherent properties of space, matter, energy and their interactions (see Science). Engineering is the application of objective knowledge to the creation of plans, designs, and means of achieving desired objectives (see Engineering). Technology deals with the tools and techniques for carrying out the plans (vol. 13, 1960, p. 406).

The Encyclopaedia Britannica has no entry entitled "technology," but the Index suggests the reader "see: Automation; Engineering; Industrial Revolution, The; and Inventions and Discoveries" (Volume 24, The Index, 1965, p. 574). The Encyclopedia Americana does not even list the term "technology" in its index (Volume 30, The Index, 1963).

The World Book Encyclopedia allows five and one-half pages to the entry "technology." The center headings of the entry are: Power and Energy, Tools and Machines, Raw Materials, On the Farm, and Mass Production. Additional related subjects were suggested: "See also the following articles: Automation; Factory and Factory System; Industrial Revolution; Industry; Instrument, Scientific; Machine; Machine Tool; Manufacturing; and Mass Production" (Volume 16, 1958, p. 7923).

It can be concluded, therefore, that major encyclopedia sets do not provide any insight into the problem of conceptualizing a structure of technology. The superficial treatment of the subject was most evident.

The authors of Technology--Man Remakes His World state:

> This book is a comprehensive survey of one branch of human achievement. Its scope is encyclopedic, but its arrangement is not the alphabetic one of a conventional encyclopedia. Instead, its approach is systematic--one subject leading to another. This gives it the advantage of a natural and logical presentation. However, the present state of our technological advance is so complex that our particular approach to the subject was chosen only after a careful consideration of many possible alternatives (Brownowski, 1963, p. 9).

Thus, they view the work as being an "encyclopedic" review of the application of scientific knowledge to all man's problems, not only industrial ones.*

The sixteen chapter headings of the above volume, excepting the introduction and the summary, are listed below:

Measurement: Basic Techniques
Power: Basic Techniques
Riches of the Earth
Chemical Technology
Metals and Their Uses
Ceramics and Glass
Food and Agriculture
Textiles and Leather
Building: Materials & Methods
Land Transport
Water Transport
Air Transport
Military Technology
Communications & Control

Analysis of the above headings or structure of this book reveals a material emphasis. Medical technology is absent while destruction technology is reviewed. Even within the treatment of material technology, materials form the basis for some chapters while processes or techniques form the basis for others. In this same vein, metals and ceramics apparently are not part of the "Riches of the Earth." This beautifully done volume is representative of the best of several works of its type which were reviewed, but it does not suggest a viable structure of technology for instructional purposes.

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*The authors did not equate technology with praxiology. That is, they saw technology simply as the application of selected scientific principles to the solution of human problems. As indicated earlier, this view fails to account for the remainder when science and practice are subtracted from technology.

Industrial Arts Curriculum Theorists. The point has been made that the majority of contemporary thinking would support the contention that industry is the source of content for industrial arts. Several prominent curriculum proposals have been made which recommend that industry or industrial technology be the source of content but with the major purpose of reflecting the technology. These proposals have been developed by Warner, the State of Florida, and Olson.

Through examination of census and other economic data since 1925, Dr. William E. Warner and graduate students at The Ohio State University have posited six large divisions of subject matter resources that would reflect the technology. These are Power, Transportation, Communication, Manufacture, Construction, and "several human, organizational and administrative factors referred to as Management" (Warner, et al., 1965, p. 5). These divisions were first proposed formally in 1947.

That this proposal had immediate appeal to some in the profession was evidenced by publication in 1948, in the State of Florida, of A Guide to the New Technology in Industrial Arts. This guide proposed ". . . five broad realms of human experience, power, transportation, communication, construction, and manufacture" (Florida State Department of Education, 1948, p. 14). This was a plan considered by many as an ideal to strive toward, rather than as an operational plan for the present. To support this point, a revised edition of the bulletin appeared in 1959 which related:

> The Florida industrial arts curriculum is now based on areas involving materials of graphics, woods, metals, electricity, mechanics, and crafts. This organization is intended to promote the modern concept of industrial arts. These materials relate to the five broad realms of human experience: communication, construction, manufacturing, transportation, and power . . .
>
> The industrial arts curriculum proposed in the second edition of Bulletin 12, published in 1948, is still a continuing goal of curriculum organization for industrial arts (Florida State Department of Education, 1959, p. ix).

Delmar W. Olson in his book Industrial Arts and Technology postulates eight categories of industries which, if implemented in the school program of industrial arts, would reflect the technology. These are: manufacturing, construction, power, transportation, electronics, research, services, and management (Olson, 1963, p. 95). Olson's proposal is an outgrowth and further extension of his study with Professor Warner.

One contemporary writer, Paul W. DeVore, espouses the position that technology is the foundation and the source of content in industrial arts. Whereas Warner and Olson have taken an intermediate position and have conceptualized structures of industry to reflect the technology, thereby making no claim for a comprehensive coverage of all of technology, DeVore proposes that industrial arts is essentially the study of technology. He writes:

> . . . Although we have identified technology as having a body of knowledge we have not shown its organization or structure. Both of these are necessary elements since a discipline by definition is developed by instruction.

> An organizational structure is easily identified; however, it is a structure having both durability and continuity and is easily determined by a review of man's major technical endeavors through the centuries of his technological development.
>
> His major areas of technical endeavor identify man(1) as a builder, (2) as a communicator, (3) as a producer, (4) as a transporter, (5) as a developer, (6) as an organizer and manager of work, and (7) as a craftsman.
>
> Using these basic divisions of man's technical endeavors as a structure, it is possible to study the discipline of technology and meet the challenge of the future . . . (DeVore, 1964, p. 14).

An examination of this structure indicates that DeVore has ruled out, for example, man the destroyer, or man the healer. Technology, as it may be equated with praxiology, and technology, as structured by DeVore, are of different orders. By comparison, DeVore's structure includes only a portion of the knowledge of man's practices, but it extends beyond the limits of industrial technology as defined in this work.

DeVore's position is that technology is an intellectual discipline. Rather, technology might be considered to be a broad realm of study made up of several disciplines. Usage parallel to his implies, at the same level of generality, that science, the arts, or the humanities are intellectual disciplines. More commonly, each of these broad realms or domains of man's knowledge is considered to be made up of many disciplines.

Yoho states, "A network model . . . of our total functioning society should be useful for revealing the very roots of all education programs" (Yoho, 1965, p. 34). His network model then lists communication as the means by which a functioning society provides for four basic life purposes:

production and consumption of goods and services, discipline-government, perpetuation-health-recreation, and culture continuity (Yoho, undated, p. 3). This system fails to account for the basic social institution of religion unless it is subsumed under culture continuity.

Yoho's model may be considered to equate the production and consumption of goods and services with the economic institution. His further breakdown of this division of the model lists: (1) extractive industries, (2) distributive industries, (3) business, (4) manufacturing industries, (5) service industries, (6) construction industries, (7) communication industries, (8) personal services, and (9) home apprenticeship (Yoho, 1965, p. 35). These elements are not unlike the Standard Industrial Classification system divisions. However, he subsumes transportation under distributive industries, separates personal services from service industries, and apparently equates "business" with "finance, insurance, and real estate" and "distributive industries" with "wholesale and retail trade" plus transportation.

After presenting his model, he states:

> Manufacturing industries, service industries, construction industries, and communicative industries encompass the unique responsibility areas for the general industrial arts program and should be the basis for organization and selection of instructional content rather than the present diverse areas which have no consistent basis for derivation and delimitation (Yoho, 1965, p. 86).

Thus, from the total activities of the economic institution he has selected the production of goods (manufacturing and construction), plus selected service industries, plus communication industries, to represent industry. His reason for including communication and excluding transportation is unclear. One distributes information, the other goods or people, but neither produces material products. The reason for selecting some services and for excluding others is equally unclear.

Institutions of Higher Education. Finally, an analysis of the organization of a large, land grant university conceived and chartered to advance the practical arts, should provide insights regarding an adequate structure for the organized study of technology. One might even presume that this type of university would pattern its organization on the basis of some consciously derived structure of technology. In fact, neither the land grant universities nor the specialized institutes of technology have been developed on this basis. They have evolved in response to various changing demands and pressures. State and federal legislation, demands by employers, the availability of competent staff, the development of vested interests by individuals and groups on the staff, and budgetary restrictions are prominent among a host of problems with which university administrations must cope. A resultant construct is represented in Figure VI by a listing of the technology-oriented degrees, and subject matter majors within degrees, at one of the large land grant universities. Academic degrees which are not directly related to the preparation of students for specific employment are omitted, because they are not relevant to this analysis.

Even a brief review of Figure VI will reveal that health technology is spread through several colleges (Colleges of Medicine, Pharmacy, Veterinary Medicine, Education, Dentistry). Similarly, programs related to industrial technology may be found in the Colleges of Arts and Sciences, Agriculture, Commerce, Education, and Engineering. The organization of programs of study as illustrated in Figure VI presents a confused picture of the nature of technology. Similarly, the specialized institutes of technology, such as the representative one whose program is shown in Figure VII, have grown in response to various demands and pressures and reveal no consistent or defensible structure for a generalized study of technology.

The review of existing structures of technology warrants a conclusion that they are not conceived broadly enough to provide an adequate structure to embrace the knowledge of all of the practices of man. Each of these structures may have been adequate to serve its respective purposes, but all of them were found wanting when they were examined in terms of the purposes of this Project. Therefore, an adequate structure of technology (praxiology) is presented in the next major section of this chapter.

Industry as a Societal Institution. Another major conceptual problem, in addition to the provision of an adequate conceptualization of the dimensions of praxiology (technology), is the clarification of precisely what are the dimensions of "industry."

Industry is one of the most dynamic societal elements in the modern world. Intelligent citizens should understand their societal environment. Thus, it is imperative that students be provided with the opportunity to gain an understanding of industry. Fundamental to this understanding is a logical conceptualization of industry and its relationships with other societal institutions.

Figure VI

Action-oriented Bachelor Degrees and Majors in The Ohio State University (1964)

ege of Dentistry

- chelor of Arts*
  Dental Hygiene
  ajor)
- chelor of Science
  Education* (to
  ach Dental Hygiene)

College of Education

- Bachelor of Science in Education
  - Elementary Ed.
  - Secondary Ed.
    - Area of Specialization
      - Art Ed.
      - Biological Science
      - Business Ed.
      - Chemistry
      - Dental Hygiene Ed.*
      - Distributive Ed.
      - Earth Science Ed.
      - English
      - French
      - German
      - Industrial Arts Ed.
      - Latin
      - Library Science
      - Mathematics
      - Music
      - Physical Ed.
      - Physics
      - Psychology
      - Radio-Television Speech Ed.
      - Russian
      - Science Ed.
      - Social Studies
      - Spanish
      - Speech and Hearing Therapy
      - Teaching of Blind & Partially Seeing
      - Trade & Industrial Ed.
- Bachelor of Science in Occupational Therapy*
- Bachelor of Science
  - Psychology
- Bachelor of Arts
  - Fine Arts
  - History of Art
  - Studio Work (art)
  - Music
  - Psychology
- Bachelor of Fine Arts
  - Specialization
    - Ceramic Art
    - General Fine Arts
    - History of Art
    - Medical Illustration
    - Painting
    - Product Design
    - Sculpture
    - Space and Enclosure Design
    - Visual Communication Design
- Bachelor of Music
  - Applied Music
  - Theory-Composition
  - Church Music

College of Engineering

- Bachelor of:
  - Aeronautical & Astronautical Engineering
  - Agricultural Engineering*
  - Architecture
  - Ceramic Engineering
  - Chemical Engineering
  - Civil Engineering
  - Electrical Engineering
  - Engineering in Mining
  - Industrial Engineering
  - Landscape Architecture
  - Mechanical Engineering
  - Metallurgical Engineering
  - Science in Physics
  - Welding Engineering

College of Law

- Bachelor of Laws

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College of Law

- Bachelor of Laws

College of Medicine

- Bachelor of Science in:
  - Medical Dietetics
  - Medical Technology*
  - Nursing
  - Occupational Therapy*

College of Pharmacy

- Bachelor of Science in Pharmacy
  - Professional Pharmacy
  - Hospital & Industrial Pharmacy
  - Preparation for Graduate Study

College of Veterinary Medicine

- Graduate Degrees Only

Figure VII

Bachelor Degrees and Majors
DREXEL INSTITUTE OF TECHNOLOGY
Philadelphia, Pennsylvania

College of Business Administration

- Bachelor of Science in:
  - Field of Concentration
    - Business Administration or Commerce
      - Accounting
      - Business Teacher Training
      - Economics
      - Electronic Data Processing
      - Executive Secretarial
      - Finance
      - General Business
      - Management and Industrial Relations
      - Marketing
      - Retail Management

College of Engineering and Science

- Bachelor of Science in:
  - Chemical Engineering
  - Civil Engineering
  - Electrical Engineering
  - Mechanical Engineering
  - Metallurgical Engineering
- Bachelor of Science
  - Major
    - Biological Science
    - Chemistry
    - Mathematics
    - Physics

College of Home Economics

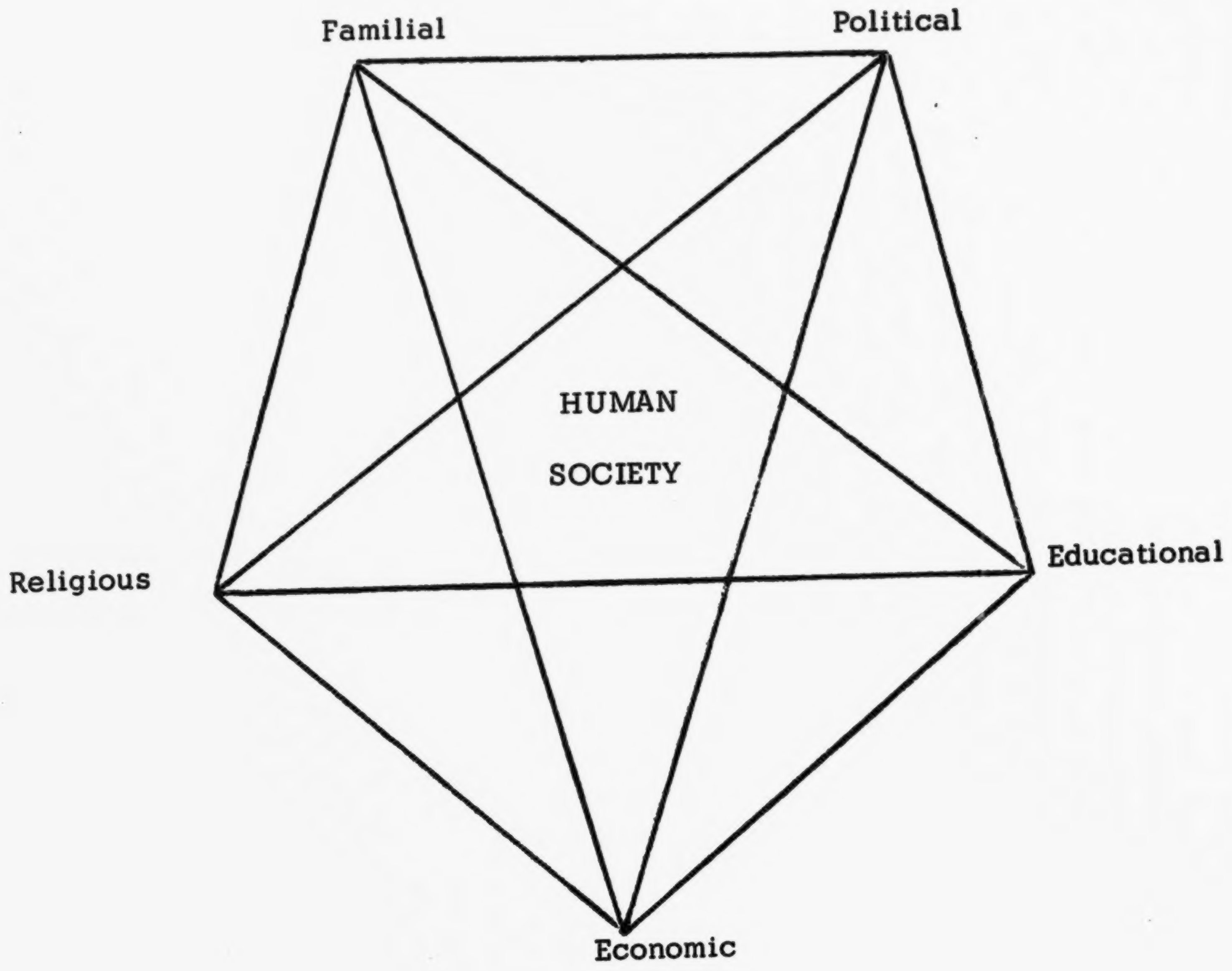
- Bachelor of Science
  - Major
    - Consumer Food Service
    - Dietetics and Institutional Management
    - Fashion Design
    - Fashion Merchandising
    - General Home Economics
    - Home Economics Education
    - Interior Design
    - Medical Technology
    - Nutrition and Food
    - Restaurant and Hotel Administration and Food Management
    - School Food Service
    - Textiles, Sciences, and Clothing

As indicated earlier in the section on definitions, some have equated industry with the economic institution of society. A study of societal institutions does not warrant this usage. Figure VIII graphically portrays the interrelationship of the generally accepted fundamental institutions of society. The place of industry, as a sub-element of this construct is unclear. However, an understanding of industry is predicated upon the power or ability to discern particulars in relation to some meaningful whole, and a means to the provision of this understanding is the ultimate purpose of this Project. Thus arises the need to conceptualize the economic institution with industry as a subcategory of it.

According to Berelson and Steiner (who also use the five basic societal institutions shown in Figure VIII and add a sixth, the military institution) the term institution "is given different definitions by scholars of different proclivities." They then indicate that the distinction in usage of the term, " . . . roughly speaking, . . . is between the procedures and the system" (Berelson and Steiner, 1964, p. 384). Thus, some call both the economic system and industry societal institutions. Others would distinguish between them by designating the economic system an institution and by designating industry as one pattern of procedures employed in the economic institution. For purposes of further clarification, both the family and marriage may be termed institutions, or alternatively, marriage may be conceived as being a procedure ("complex normative pattern") in the familial institution ("the organized aggregate to which the norms are applied").

Figure VIII

BASIC SOCIETAL INSTITUTIONS


Familial
Political
HUMAN
SOCIETY
Religious
Educational
Economic

Acknowledging the above difficulty, industry herein is defined as a societal institution, in accordance with one selected use of the term "institution," that of a "complex normative pattern" leading toward a particular set of goals. This should pose no problems as long as the economic institution is recognized as being one of a higher order as compared with industry.

All societal institutions interact, as indicated by the multi-directional interconnecting lines shown in Figure VIII. In a given society, the interrelationships between the various major and lesser order institutions will vary. Thus, the interaction between religion and government in one society may be marked; in another it may be very slight. Also, in studying industry in the United States, the discernible relationships between government and industry would differ markedly from those found in a study of industry in the Soviet Union. Therefore, one may study industry on a national or a comparative basis. More adequate understanding results from the latter, for only then can the learner know the reality of industrial practices in a given society and the effect of the manipulation of variables. However, a comparative study of industry in various societies has not been advanced as a superior way to broaden or extend the study of industry in industrial arts.

Perhaps because industry has not been perceived within the context of the economic institution within the total social matrix, attempts to broaden the study of industrial arts thus far have been based upon the addition to traditional studies of selected elements of the economic institution in the

United States. This approach invades the subject matter of existing school subjects such as business education, economics, or distributive education. In addition, it fails to clarify the scope and nature of industry or its interrelationships with other elements of the economic institution.

A structure of the economic institution which lends intelligibility to its function is depicted in Figure IX. Society has developed this particular institution to provide its economic goods, commonly divided into goods and services. This dichotomy is fallacious for the purposes of this Project. Therefore, in Figure IX, economic goods are divided into material production and other economic activity.

Even a casual review reveals that agricultural services are rendered by agriculture. To separate the practices of tree pruning or plowing from agricultural production because they are sometimes provided as services off the farm serves little or no function in communicating the theory of the practices. Similarly, to separate the practices of appliance repair from industrial production because they are sometimes performed in the home would serve no logical purpose in organizing the theory of those practices.

Services are provided by all the elements of the economic institution, thereby the term fails to qualify as a discrete category among the elements. As agriculture and industry provide services, so do banks, advertising agencies, and the schools. On this point, the Standard Industrial Classification Manual cannot be used for the purposes of this Project. Some establishments do engage primarily in service, and, for purposes of gathering data relative to their economic significance, a service category for these data may be appropriate. However, on a logical basis, particularly with reference to the source and nature of the practices of servicing material goods, services are integral to the material production elements which develop and refine the service practices.

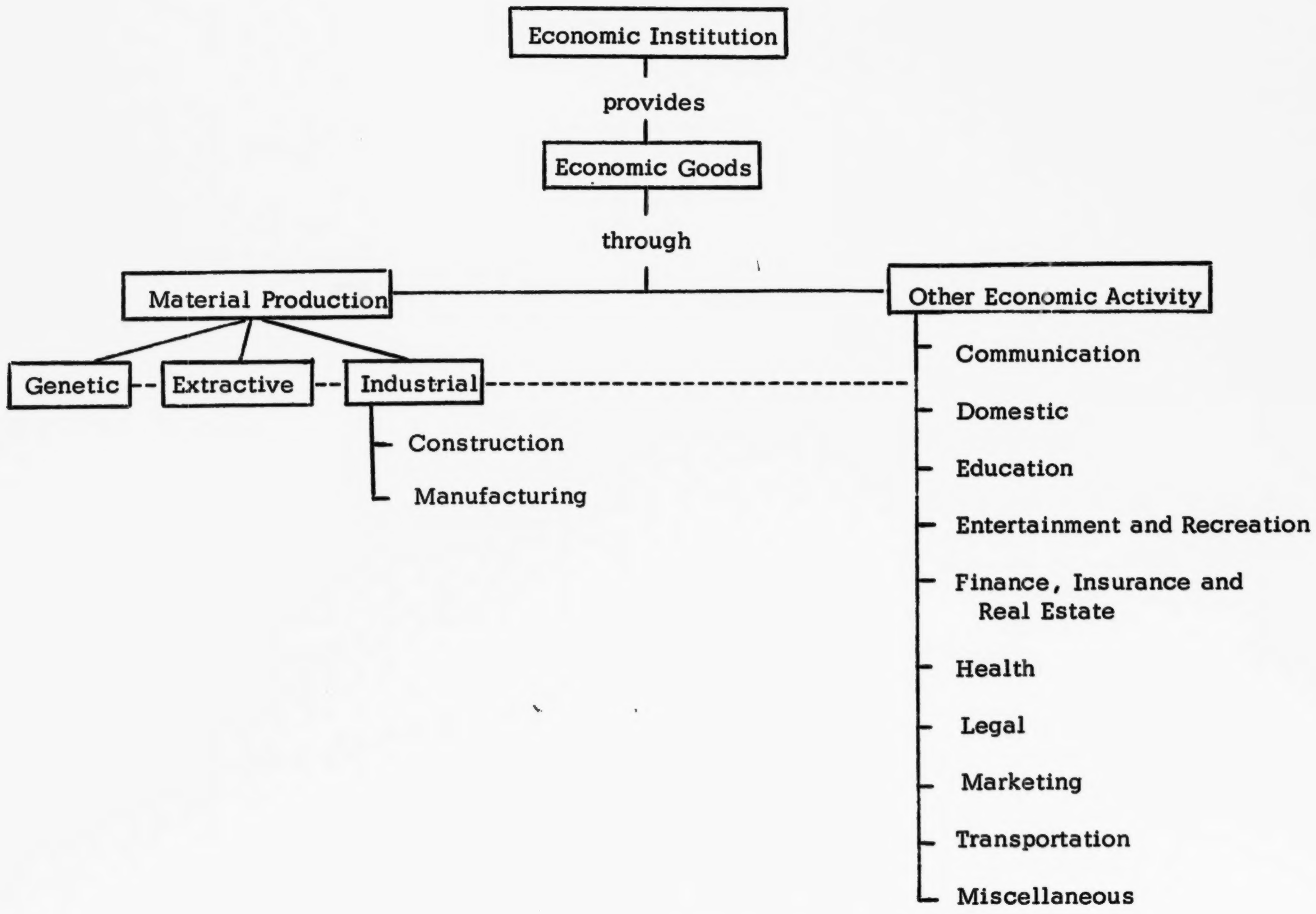
In view of the above, the term "services" does not appear in Figure IX. The elements of the economic institution all are considered to possess service practices which appropriately are studied within the total context of each particular element. Thus, manufacturing and construction services are structured and would be studied as part of each respective element.

Within the economic institution industry may be conceived as being that institutional element which substantially changes the form of materials to satisfy man's material wants. Industry essentially includes construction and manufacturing. While agriculture and mining also are engaged in material production, they do not essentially change the form of the materials produced. For this reason, they may be designated genetic or extractive material production, that is, they genetically reproduce materials or withdraw them one time from natural resources.

Utilities commonly are structured as separate categories or in conjunction with selected services (see Figure III). Utilities do not appear in this manner in Figure IX. Rather, they are subsumed, in manufacturing or in construction, as they relate to material production. Thus, the conversion of coal to steam to kilowatt hours of power is a manufacturing function, as is the operation of a waste treatment plant. On the other hand, the building

Figure IX

ELEMENTS OF THE ECONOMIC INSTITUTION


Economic Institution
provides
Economic Goods
through
Material Production
Other Economic Activity
Genetic
Extractive
Industrial
Construction
Manufacturing
Communication
Domestic
Education
Entertainment and Recreation
Finance, Insurance and Real Estate
Health
Legal
Marketing
Transportation
Miscellaneous

of manufacturing or sanitary facilities is construction.

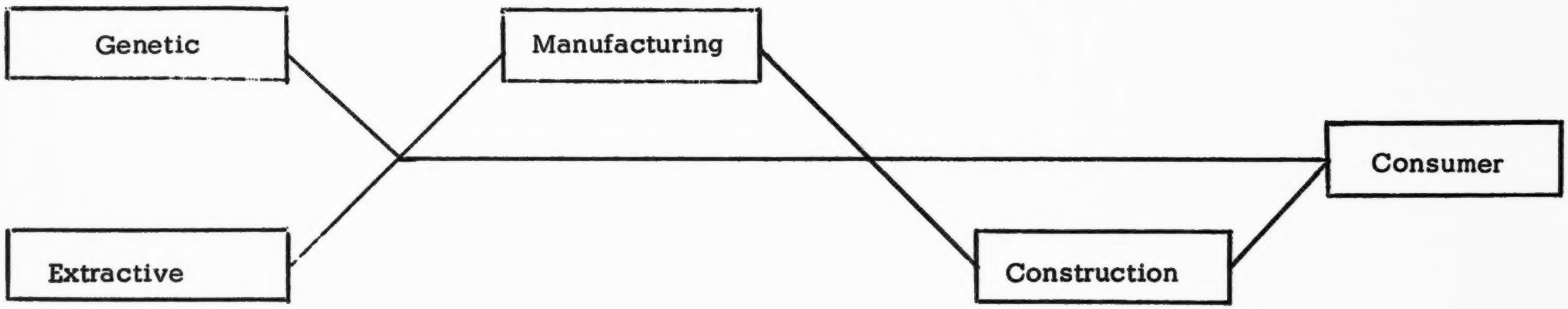
Figure X presents the material production continuum which clarifies the relationships between the elements of material production. The genetic or extractive material production of agriculture, forestry, fisheries, mining, etc., may either provide materials to industry (construction and manufacturing) which substantially change the forms of these materials, or their production may be provided directly to the consumer. For example, peas may be sold fresh to the consumer or be processed in industry and then be distributed to the consumer. Similarly, coal may be provided directly to the consumer or it may be manufactured into briquets or converted to kilowatts and then passed to the consumer. Gravel may be provided directly to the consumer or it may be processed by manufacturing and construction to concrete and to a structure, respectively.

Industry does not provide services except as they are related to material goods. These material goods are serviced by installing, maintaining, repairing, and altering them. Industry also provides much of the body of knowledge used by those service establishments and individuals engaged in the servicing of material goods. That is, when industry produces automobiles or buildings, it usually provides the theory of practice for their efficient installation, use, alteration, maintenance, and repair by consumers, operators, and service men. Industry produces this body of knowledge and for this reason it is a part of the study of industry.

In accordance with the above, a study of aircraft production, as part of a study of industry, would include all that is involved in producing and

Figure X

THE MATERIAL PRODUCTION CONTINUUM


Genetic
Extractive
Manufacturing
Construction
Consumer

servicing aircraft. It also includes the development of operating practices and maintenance and repair practices. Industrial praxiology (technology) would not include a study of how an airline is planned, organized, and controlled or how it produces economic goods (transports people or products).

Only the practices employed in the management and the production of industrial material goods constitute the elements of the body of knowledge which is industrial praxiology (technology). The subject matter of industrial arts should be selected from this body of knowledge.

Provided with a detailed structure of industrial praxiology (technology), industrial arts curriculum planners can define their body of knowledge and distinguish it from other elements of man's knowledge, particularly from knowledge of the total economic institution. However, when other studies are not provided to enable the learner to understand the total economic system--from initiation through satisfaction of human wants--the study of industrial arts may be expanded appropriately.

Perhaps it should be mentioned again that the body of knowledge which is industrial praxiology (technology) is the codification of the principles of industrial practice. It is the organized body of knowledge which is the source of subject matter for industrial arts. In addition, this same body of knowledge is the source of subject matter for industrial-vocational education, engineering, and industrial relations, to mention a few. The purposes of the curriculum workers, perhaps modified by the purposes of others, will determine what part of the body of knowledge will be selected and taught at a particular time, and the purposes of the learners will determine how the knowledge will be used. This only further points out the necessity for cooperative effort at least on the part of all who would profit directly from a detailed structuring of industrial praxiology (technology); that is, those who teach it. Beyond that, those who would indirectly benefit, workers in the totality of praxiology (technology) and even in the totality of man's knowledge, should also contribute to a long-overdue effort to lay an adequate foundation for this important area of man's knowledge.

THE IACP STRUCTURE OF PRAXIOLOGY (TECHNOLOGY)

At this point it may be concluded that existing, prominent systems for classifying technology and a review of the vast literature on or related to the subject do not provide an adequate structure of technology as it may be equated with praxiology. This conclusion further verifies the generally accepted rule that classification systems reflect the purposes for which they were developed. Because the systems and the literature reviewed were not developed to organize knowledge for a broadly conceived study of praxiology (technology), they do not serve this purpose. However, each of the reviewed classification systems was the product of extensive and expert study and action. Together they constitute invaluable resources in the conceptualization and development of an adequate classification of praxiology (technology) for instructional purposes.

Criteria for an Adequate Structure. Much has been written about criteria for the development of classification systems. Werkmeister summarizes this by stating:

> Traditional logic, furthermore, has formulated at least five distinct rules which should govern all classification. But of all these rules only one is really important, the rule, namely, that in any classification the different species of a given genus should be mutually exclusive. That is to say, if we arrange our facts in groups, these groups must not overlap. All other so-called "rules of classification" are adequately covered by the general stipulation that the value of a classification is determined by its successes or failure in achieving the purpose which was intended (Werkmeister, 1948, p. 274).

Expanding only slightly on the above, the following criteria need to be applied in the conceptualization of an adequate classification system or structure of praxiology (technology) for instructional purposes:

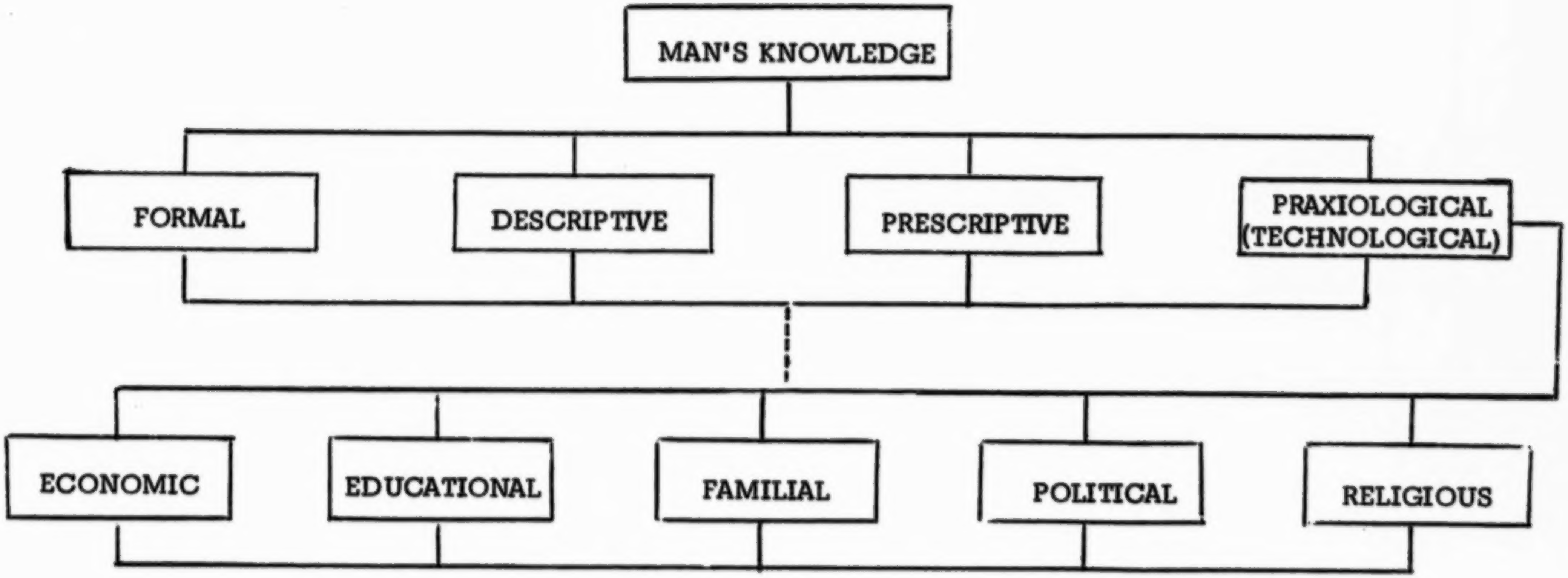
1. it includes all practices which affect humans and materials
2. it has mutually exclusive subcategories
3. it is operationally adequate for instructional purposes.

An Adequate Structure of Praxiology (Technology). Figure XI presents graphically an adequate structure of praxiology (technology), for the purposes of this study, and the interrelationships between man's knowledge and praxiological (technological) knowledge. A complete and detailed structuring of praxiology (technology), so the related disciplines and voids in this body of knowledge can be identified, remains as one of the most important tasks confronting educators.

In brief, there are many problems related to the structuring of the body of praxiological (technological) knowledge. Aspects of these same problems: terminological, methodological, historical, conceptual, also will be encountered in the development of subcategories of the structure. These problems can be recognized; they also need to be confronted and resolved.

Figure XI

The Relationship of Praxiology (Technology) to Man's Knowledge
and to the Basic Societal Institutions


MAN'S KNOWLEDGE
FORMAL
DESCRIPTIVE
PRESCRIPTIVE
PRAXIOLOGICAL (TECHNOLOGICAL)
ECONOMIC
EDUCATIONAL
FAMILIAL
POLITICAL
RELIGIOUS

Criteria for an Adequate Structure of Industrial Praxiology (Technology). The criteria for an adequate structure of industrial praxiology (technology) are essentially those applicable to an adequate structure of praxiology (technology). The former criteria are listed below with only the adjective "industrial" appropriately inserted in the first criterion. These criteria will serve in deriving an adequate structure for instructional purposes:

1. it includes all industrial practices which affect humans and materials
2. it has mutually exclusive subcategories
3. it is operationally adequate for instructional purposes.

Resources for Identifying the Knowledge of Industrial Practice. As industrial praxiology (technology) involves the organized or disciplined study of practice, a number of disciplines can be identified which would provide elements of the study. The particular disciplines which are most directly related are engineering and industrial relations (including personnel, management, and labor).

The various identifiable disciplines in higher education which directly relate to industrial praxiology (technology) will make contributions to that body of knowledge. However, even collectively, the disciplines of chemical engineering, aero-space engineering, industrial medicine, industrial engineering, industrial anthropology, industrial psychology, industrial sociology, et al., will not provide all the requisite knowledge. As stated in Chapter I, "the disciplines of practice at the collegiate level are major but not all inclusive sources of such content." Even the individual disciplines, such as industrial psychology, are forced by the requisites for controlled research to pursue isolated topics such as motivation or fatigue or even sub-topics of these. The challenge faced by these disciplines is so great that they presently must be satisfied with less than a massive, coordinated program of research.

Not only are the resources inadequate to a complete investigation of this subject matter (given an adequate structure of the body of knowledge to organize the search), but the tools themselves are inadequate, particularly in the area of investigation of the practices which affect humans who work in industry.

Apropos this point Nagel writes:

> In no area of social inquiry has a body of general laws been established, comparable with outstanding theories in the natural sciences in scope of explanatory power or in capacity to yield precise and reliable predictions . . . It is also generally acknowledged that in the social sciences there is nothing quite like the almost unanimity commonly found among competent workers in the natural sciences as to what are matters of established fact, what are the reasonable satisfactory explanations (if any) for the assumed facts, and what are some of the valid procedures in sound inquiry. Disagreement on such questions undoubtedly occurs in the natural sciences as well. But it is usually found at the advancing frontiers of knowledge . . . In contrast, the social sciences often produce the impression that they are a battle ground for interminably warring schools of thought, and that even subject matter which has been under intensive and prolonged study remains at the unsettled periphery of research (Nagel, 1961, pp. 447-48).

The identification and structuring of industrial praxiology (technology) which affects materials may be done more precisely as regards the details of the structure, but a major organizational problem exists even here. It may be presumed that the collective branches of engineering may provide the elements of a structure of this knowledge. However, engineering has developed, as may be expected of a professional vocational program, in response to the needs of employers. "The position of the engineer as a company employee, as contrasted with an independent professional, will probably persist indefinitely as the primary organization-environment for the engineering practitioner" (Study Committee on Goals of Engineering Education, 1964, p. 8). The career demands on engineers form the basis for organizing engineering studies. As a result, the organizational pattern of engineering education provides an inadequate structure of industrial praxiology (technology). The inadequacies are essentially the same, in the above case, as those which would result from attempting to structure praxiological (technological) knowledge according to the organizational pattern of higher educational institutions.

That there is an organizational alternative for engineering is evidenced by the departmental organization of the new (opened during the 1964-65 school year) College of Engineering, Chicago Circle Campus, University of Illinois. They have departments of Physics, Materials Engineering, Energy Engineering, Information Engineering, and Systems Engineering. They are currently planning to offer only two degrees in the engineering college: Bachelor of Science in Physics and Bachelor of Science in Engineering, with majors in materials, energy, information, or systems. This new organizational structure provides for a more comprehensive approach to industrial praxiology (technology) than does a structure organized on the basis of historical divisions of engineering which periodically have emerged after the first bifurcation of military engineering to military and civil engineering.

Despite the challenging problems which must be overcome, the marshalling of resources to conceptualize an adequate structure of industrial praxiology (technology) remains as the most urgent need in industrial arts. The conceptualization of this structure is the task to be undertaken in the next two chapters.

CONCLUDING STATEMENT

Presently the subject matter of industrial arts is ill-defined and a viable structure of its body of knowledge is not in evidence. A review of existing or implied structures of the body of knowledge confirms this claim. Without such a structure, progress effectively is blocked.

Praxiology (Technology) is the knowledge of practices in all of man's societal institutions, one of which is the economic institution. One element of the economic institution is industry. The knowledge of industrial practices, industrial praxiology (technology), is the source of industrial arts subject matter.

If industrial arts in our schools is to fulfill its promise as the primary communicator of the phenomena of industry as a societal institution, it must conceive and adopt an adequate structure of its body of knowledge and subsequently of its subject matter. The conception and delineation of such a structure is the remaining task of the initial phase of this Project.

In the remainder of this document and in future ones of this Project, the term "technology" will be used in the place of praxiology, as explained in the section "Technology vice Praxiology." An attempt was made in this Chapter to constantly remind the reader that technology may be equated with praxiology, and in this Project it has been and will be.

Chapter III

Structuring Industrial Technology

The procedure of developing a conceptual framework through which industrial practices may be better understood began with a search for a structure of man's knowledge. Four major realms of knowledge were identified: formal, descriptive, prescriptive, and praxiological (technological). The latter is defined as the knowledge of man's practices. The scope and importance of praxiology (technology) were investigated, and an appeal was made for a more substantial and disciplined treatment of this realm of knowledge in contemporary education.

The next step in the development of a conceptual structure involved an inquiry into the nature of praxiology (technology). Central to this task was the problem of terminological ambiguity. An examination of the meaning of "technology" and "industry" in terms of contemporary usage revealed considerable inconsistency. As a result of the present inquiry, the term technology was equated with praxiology. Industry was defined as " . . . that subcategory of the economic institution which substantially changes the form of materials in response to man's wants for material goods." The compound term industrial technology was then defined as " . . . that subcategory of technological knowledge which is derived from the study of industrial practices." A thorough examination of available resources related to the structuring of technology suggested the following criteria for an adequate structure of industrial technology:

1. It includes all industrial practices which affect humans and things.
2. It has mutually exclusive subcategories.
3. It is operationally adequate for instructional purposes.

Industrial technology, thus delineated, is advanced as the body of knowledge from which content in industrial arts should be derived. The remaining problem is to develop an appropriate structure for industrial technology.

To accomplish this task, the following were analyzed: (1) the historical development of industrial arts curriculum in terms of implicit or explicit structures for the body of knowledge; (2) systems of classifying industrial practices designed by governmental agencies and private organizations; and (3) the work of curriculum projects in other subject fields, in terms of the structures developed for their bodies of knowledge. After making these analyses, a new structure for the body of knowledge in industrial technology is conceptualized.

EARLY INDUSTRIAL ARTS CURRICULUM PROPOSALS

Industrial arts has been used as the name of a curriculum area in education only in the twentieth century. However, formal schooling in industrial practices dates back to a much earlier period in the history of American education and reflects, with its own unique adaptations, extensive and multifarious lineage in European educational thought and development.

To transmit the accumulated knowledge of industrial technics from one generation to the next has always been of concern; since the most primitive time this transmission has been mandatory for race survival and progress. Before the latter part of the nineteenth century, the conscious intent of this transmission had been predominantly vocational rather than liberal and general, and it was presumed to be largely a responsibility of the family, or a craft group, rather than of the school.

Prior to 1880 the liberal arts aim of learning for the sake of knowing about the forces which control us had not been applied to industrial study in any significant way. Also, such study generally had not been considered a requirement for intelligent citizenship. The principal industrial study had been vocational training through apprentice imitation of the master craftsman. What the master knew was transmitted to the learner through observation and practice in direct connection with the usual jobs that were part of the master's everyday routine. The goal was that the educational product should become as nearly like the master craftsman as observation and imitative practice could make him.

When industrial practices were first contemplated as liberal studies in the formal school, they were organized according to the only precedent for content organization, the cluster of tool operations and material manipulations that constituted the sequential activity of the tradesman. Categorization of courses was in terms of the skilled trades. The completed unit jobs that were commonly performed by each trade became the subdivisions, and it was considered important that the products be saleable.

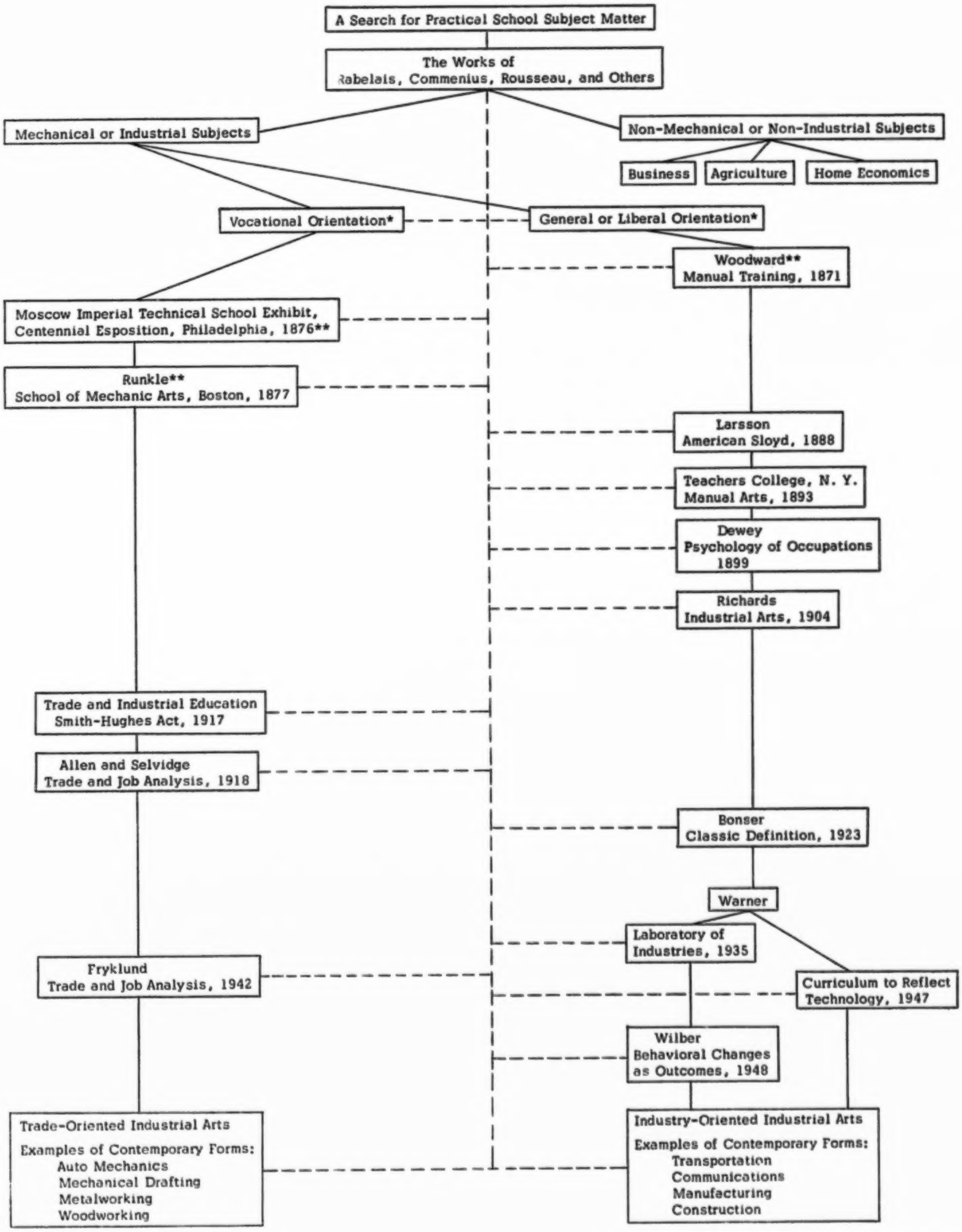
A system of instruction with these key characteristics was not well suited to group instruction by a teacher in a laboratory, and there was a wasteful use of time imposed by the need to insure that the completed product met the demands of the buyer. Also, both the liberal and the vocational education value of such study remained suspect. In the 1870's, several educators were aware of the need for improvement. One of these (Woodward) sought a way to discipline psycho-motor faculties as an essential part of liberal education. Another (Runkle) sought a way to teach trade skills for vocational purposes (either for engineers or tradesmen). Each began related but essentially different curriculum developments as indicated in Figure XII.

These parallel curriculum developments have affected each other, but a synthesis of them has not developed. In the main, contemporary industrial arts curricula reflect a vocational orientation and a trade content base; but the search continues for a more satisfactory liberal education program for all the citizens of our technological culture. From the outset, this has been the expressed primary purpose of industrial arts.

The Russian System. The Imperial Technical School of Moscow provided an educational display at the 1876 Philadelphia Centennial Exposition. Its impact on industrial studies in the United States was extensive and enduring. The small exhibit was of models arranged in sequence of

Figure XII

EARLY CURRICULUM DEVELOPMENT IN INDUSTRIAL ARTS


A Search for Practical School Subject Matter
The Works of Rabelais, Commenius, Rousseau, and Others
Mechanical or Industrial Subjects
Non-Mechanical or Non-Industrial Subjects
Business
Agriculture
Home Economics
Vocational Orientation*
General or Liberal Orientation*
Woodward** Manual Training, 1871
Moscow Imperial Technical School Exhibit, Centennial Esposition, Philadelphia, 1876**
Runkle** School of Mechanic Arts, Boston, 1877
Larsson American Sloyd, 1888
Teachers College, N. Y. Manual Arts, 1893
Dewey Psychology of Occupations 1899
Richards Industrial Arts, 1904
Trade and Industrial Education Smith-Hughes Act, 1917
Allen and Selvidge Trade and Job Analysis, 1918
Bonser Classic Definition, 1923
Warner
Laboratory of Industries, 1935
Fryklund Trade and Job Analysis, 1942
Curriculum to Reflect Technology, 1947
Wilber Behavioral Changes as Outcomes, 1948
Trade-Oriented Industrial Arts
Examples of Contemporary Forms:
Auto Mechanics
Mechanical Drafting
Metalworking
Woodworking
Industry-Oriented Industrial Arts
Examples of Contemporary Forms:
Transportation
Communications
Manufacturing
Construction

*The curriculum workers on the right were seeking a program of study which expressly denied a primary concern for the vocational value of the skills and knowledge which were taught. The curriculum workers on the left may have sought general educational goals, but their essential concern was always on the trade validity of what was taught.

**Runkle observed the Russian display in Philadelphia and saw it as the answer to his search for a means of organizing trade skills. Woodward became aware of this work and took advantage of it, but his purpose remained non-vocational--to broaden the liberal education base. The 1877 School of Mechanic Arts was a vocational school. The 1880 Manual Training High School in St. Louis was not.

difficulty. These models represented the necessary manipulative exercises for progression from little skill to higher levels of skill in the use of tools. Significantly, the models had little if any functional purpose; they were not parts of a machine or any other useful object. These exercises were selected so as to include all of the basic elements of the mechanic arts.

Victor Della Vos and other instructors who developed the program made no effort to justify it as liberal arts. The search by the Russians was for an organization of mechanical arts content that would enable more efficient teaching and more rapid learning of the manipulative skills of the tradesman.

Their contribution consisted of an analysis of what appeared to be complicated products of the various craftsmen's efforts. The analysis revealed that the apparent complexity could be reduced to a relatively few general types of tools and processes. These could be taught and learned in isolation from any trade job or routine and without regard to any defined trade, and yet would provide the foundational capability for any trade. In the educational terms of that day, the analysis produced an alphabet of mechanic arts which, once learned, could be put together in any number of combinations to produce the completed job which the tradesman might later be called upon to perform.

Although numerous attempts had been made to institute instruction in shopwork in American schools before 1876, nowhere had these efforts resulted in a definition or statement of purpose, or in a clear-cut identification of a body of subject matter. Consequently, it had not been possible to decipher and organize instructional content into a plan for teaching; nor was it possible to develop a pedagogical approach to operating classes for students.

The Russians had overcome all these difficulties and had placed instruction in shopwork on a basis equal to mathematics, science and other subjects. Certainly, the Russians had postulated a content universe--the mechanical trades--which is a primary condition to locating subject matter for developing a program of instruction. Moreover, they had actually identified their subject matter and had translated it into instructional content for specific courses. The courses were arranged into a progression that constituted a program of study, and each course had its own pedagogical techniques.

Runkle, then president of M.I.T., viewed the Russian exhibit and the following year opened the Boston School of Mechanic Arts, a vocational school, which employed their system. Subsequent systems for analyzing and teaching vocational industrial content have been refinements and adaptations of this basic system. The same system also has been applied in the development of the majority of contemporary industrial arts curricula, those in which the content is based on elements of skilled industrial trades. Few have challenged the Russian system as a basis for deriving industrial arts subject matter, even though the subject matter of industry has long been of vastly greater scope than any composite of the knowledge employed by selected skilled tradesmen or the totality of them.

Manual Training. In 1871, Calvin Woodward observed that his mathematics students were unable to construct simple three-dimensional models using common hand tools. He believed this indicated there was a serious shortcoming in their general education, and he became interested in developing a school program that could teach youth basic manipulative skills. His convictions about the Russian system were stated in an address he made before a learned society in St. Louis when he said:

> To Russia belongs the honor of having solved the problem of tool instruction. Others had admitted that practice in using tools and testing materials should go hand in hand with theory; but Russia first conceived and tested the idea of analyzing tool practice into its elements and teaching the elements abstractly to a class. In their hand, manual tool instruction has become a science (Woodward, 1878, p. 3).

Within the educational context of the period Woodward sensed that it was now possible to select from the complex body of mechanical content discrete elements or manipulative operations which, in their abstracted isolation from practical jobs, would no longer be regarded as utilitarian. The manipulative procedures could now be taught as arts without the requirement of practical application. The context of the trade was no longer necessary. The manual faculties of the student could now be disciplined without resorting to the trade practices of apprenticeship and the other forms of trade education.

A violation of the criteria of liberal education would have been committed if Woodward had allowed more than the absolute minimum of science and mathematics content to be applied in the manual courses of the school's program. But there was no need for that. Content that might have been useful in the manual courses was presumed to be included in the science and mathematics courses. There it could be learned in all its purity and isolation from practical application. In the same spirit of traditional liberal arts education, Woodward's task and his place in industrial education history were concerned primarily with organizing and teaching the elements of the mechanic arts with as little semblance of application to specific trades as possible. Pure manual action was sought as the counterpart of pure science and pure mathematics. Given the realities of the human organism, manual training's content was as purely manual as it was possible to make it.

In 1879, at Woodward's urging, the Board of Directors of Washington University passed an ordinance for the establishment of the Manual Training School of St. Louis. A building was erected and made ready for classes by September 1880. Article II of the ordinance states the purpose of the school and indicates certain features of the curriculum.

> Its object shall be instruction in mathematics, drawing and English branches of a high-school course, and instruction and practice in the use of tools. The tool instruction and practice, as at present contemplated, shall include carpentry, wood turning, patternmaking, iron chipping and filing, forge work, brazing and soldering, and the use of machine shop tools, and such other instruction of a similar character as may be deemed advisable to add to the foregoing from time to time.
>
> Students will divide their working hours, as nearly as possible, equally between mental and manual exercises. They shall be admitted, on examination, at not less than fourteen years of age, and the course shall continue for three years. (Washington University, 1897, p. 9).

Despite the differences in purposes, the proposed curriculum was almost identical to that of the School of Mechanic Arts established at about this time by Dr. Runkle in Boston. The 1897-98 catalog of the Manual Training School shows that additions were made to the curriculum as follows: biology, botany, chemistry, physics, civil government, history and literature. Elective courses were offered in Latin, French, Spanish, and German. The courses in Tool Instruction, as they were termed, were: joinery, wood-carving, woodturning, patternmaking and moulding, forging, and tool-work. The last course was metal work by machine and hand tools in which each student took part in the construction of a project or finished machine which embodied a great range of tool practice and constructive skill.

The striking similarity between this program and industrial arts today hardly needs to be dwelt upon. The essence of the offering, the overall structure, and the pattern for teaching, remain. That is, even today, the respective mechanical trades for each area of industrial arts are postulated as the source of subject matter (the content universe) for shop instruction and the procedure of trade and job analysis used in the Russian system to derive and organize teaching content continues as the prevailing practice. Likewise, the procedure of group and individual instruction with prescribed projects and lessons on job knowledge related thereto remains prevalent. About the only changes that have taken place are to substitute a utilitarian project for the formalized exercises, to delete some of the tool operations because of time limits, and to de-emphasize the disciplinary aspects in teaching and learning.

Manual training, as originally conceived, had been designed to be perfectly compatible with prevailing conceptions of liberal arts education conducted within the framework of faculty psychology and formal discipline. Because the underlying faculty psychology soon was discredited and because of other pressures which are discussed next, manual training departed from its first form very soon after it was initiated. The original theory served as an expressed justifying argument only during the period when it was on trial for its young life in the educational forum of the nation. However, the basic disciplinary tenets have continued to exert influence in the industrial arts curriculum field.

Early Forces Affecting Manual Training. At the changing of the century, manual training-manual arts was an entrenched program in the secondary schools of the nation. It had slowly become qualified for a change of name, at least in its theoretical statements, by responding to a number of forces.

One of the first of these forces was educational Sloyd from Sweden. While it made no significant addition to the industrial content, the Sloyd system did recognize student interest as a psychological fact and forced acceptance by manual training of useful models as replacement for the abstract shop exercises that had formerly been thought necessary to avoid the indictment of "utilitarian." This change did not appreciably alter the disciplinary emphasis of manual training. The developments in experimental psychology, however, were able eventually to force abandonment of faculty psychology and its method of formal discipline. The principal residue of the Sloyd influence was the useful take-home model, the immediate predecessor of the hand-crafted project whose construction has persisted as the predominant activity in industrial arts education up to the present.

A second influence on the character of manual training was the Arts and Crafts Movement, with its origins in England. It was a movement of protest. As such, it decried the rise of the factory system and the industrialization of society with all the attendant problems. It sought to preserve individual craftsmanship along with opportunities for custom design and construction. It actively promoted the formation of clubs in which this kind of activity could be experienced. Its philosophy and resulting argument inferred developmental benefits that had great appeal to manual training educators in this country, causing them to adopt the new name, Manual Arts. Including aesthetic elements would strengthen the general education claims of manual arts; the application of technical fact and the exercise of trade skill in making hand-crafted articles would not weaken manual arts' contribution to economic efficiency, a value claim which had never been relinquished. In addition, the very protest against the factory system suggested to American educators that the schools could include industrial content and incorporate aesthetic experiences with that content which in some measure would compensate for the drudgery and routine that awaited many of its young charges as their occupational fate.

A third pressure, which had been continuously present since the inception of manual training, was the requirement of the economy for skilled tradesmen. Every schooling effort using industrial subject matter has had to contend in one way or another with insistent pressures for making direct contribution to occupational competency in the skilled trades. Woodward responded by declaring that in teaching the abstracted manual elements of the mechanical trades, he was preparing for all the trades. Within his psychological frame of reference, no breach of integrity existed when he also declared that manual training was liberal education. When those who followed Woodward transposed the manual content into a modernized and more adequate psychological context without essentially altering the content universe, they set a precedent which the industrial arts curriculum area has never completely overcome.

The Influence of Dewey. Before 1900, there was no serious challenge offered to the excessively manual character of the subject matter, to its sources, to its organization, or to the purposes for including it. But then a new period began. Cued by the thought of John Dewey, voices were raised in criticism and positive proposal that amounted to more than corrective change; the new trend was nothing short of a new departure for the selection and study of industrial subject matter in the elementary and secondary schools of the nation.

In the closing years of the nineteenth century, Dewey critically observed the existing educational structure in the context of a society becoming increasingly industrialized. Excerpts from a published speech to a group of parents convey the intensity of his conviction that educational change was urgent:

> The change that comes first to mind, the one that overshadows and even controls all others, is the industrial one--the application of science resulting in the great inventions that have utilized the forces of nature on a vast and inexpensive scale: . . . One can hardly believe there has been a revolution in all history so rapid, so extensive, so complete. Through it the face of the earth is making over, even as to its physical forms; . . . population is hurriedly gathered into cities from the ends of the earth; habits of living are altered with startling abruptness and thoroughness. . . . That this revolution should not affect education in some other than a formal and superficial fashion is inconceivable (Dewey, 1899, pp. 5-6).

Dewey was also keenly aware of the efforts in the area of industrial study and pronounced them inadequate:

> When we turn to the school, we find that one of the most striking tendencies at present is toward the introduction of so-called manual training, shopwork, and the household arts--sewing and cooking.
>
> This has not been done "on purpose," with a full consciousness that the school must now supply that factor of training formerly taken care of in the home. . . . Consciousness of its real import is still so weak that the work is often done in a half-hearted, confused, and unrelated way. The reasons assigned to justify it are painfully inadequate or sometimes even positively wrong. . . . We must conceive of work in wood and metal, of weaving, sewing, and cooking, as methods of living and learning, not as distinct studies.
>
> We must conceive of them in their social significance, as types of the processes by which society keeps itself going, as agencies for bringing home to the child some of the primal necessities of community life, and as ways in which these needs have been met by the growing insight and ingenuity of man.
>
> In educational terms, this means that these occupations in the school shall not be mere practical devices or modes of routine employment, the gaining of better skill as cooks, seamstresses, or carpenters, but active centers of scientific insight into natural materials and processes, points of departure whence children shall be led out into a realization of the historic development of man (Dewey, 1899, pp. 7-10).

The implications of John Dewey's educational investigations at Chicago were far-reaching and profound. Of special significance here is Dewey's concern with industrial subject matter. His educational theory took into account the ubiquitous influences of industry as a social institution. The psychological aspects of this same theory required a physically active pupil involvement with the subject matter. The manipulative subject matter of industry was to be physically experienced as content, but it was also to serve as an indispensable part of the learning method for investigating industry as an integral part of the culture.

For elementary grades the content was confined to that which had meaning and significance for that age and experience level. Certain social occupations, chiefly from industry, were selected as axial points of study. Dewey's phrase, "Psychology of Occupations," referred to the rationale which he developed to undergird the involvement of pupils in the practical affairs of the socio-economic world. He insisted that any simulation of industrial occupations must maintain a balance between the intellectual and the practical phases of the experience. He warned against the dangers of overemphasizing the manual activity for its own sake, or for the physical product which resulted.

For higher levels of education, Dewey did not spell out the schooling procedures in the practical way that he did for elementary education. However, subsequently recorded expressions of his educational philosophy recognized the increasingly important part industrial subject matter must play in democratic education for citizenship participation and for use, control, and enjoyment of industry and its bounties.

Deweyan theory made possible a radical departure from manual training-manual arts procedure in the area of subject matter for industrial study in at least two fundamental ways. First, industry (as opposed to selected skilled trades) was an important social institution whose study must be a necessary ingredient at all levels of liberal education. No part of industrial subject matter, in any of its many ramifications, need be excluded from consideration by such a study.

Second, as the learning situation required it, both manual and "intellectual" subject matter were to be experienced, but without the hierarchical categorization and isolation that was characteristic of the manual training tradition. When manual activity was employed in a natural setting of industrial content to serve educational purposes of investigation for insight and understanding, it became a part of liberal study without prejudice. Shopwork with industrial materials and appliances was taken for granted as a part of this study because it was a part of the subject matter in the real social situation. Activities with materials and appliances were subject matter to be experienced, but they were also integral parts of learning method. Dewey's theory of knowledge and his psychology of learning (experimentalism) required an active, overt, purposeful manipulation of environment.

Manual training-manual arts had built fences around the content for which it claimed responsibility. The tradition of Woodward-Runkle plus the increasing economic pressures to contribute to occupational efficiency in direct ways, had confined manual training-manual arts subject matter, in the main, to the manipulative aspects of the fabrication processes. The Deweyan criterion for selecting subject matter knew no such limitations.

If Dewey's concept of industrial subject matter was not wholly new, certainly it was of far broader scope than the one supporting the adoption and development of manual training in this country. No doubt its complexity is one reason for its having made little impression on those responsible for industrial arts curriculum planning. Be that as it may, the idea moved shop activity into the center of the educational arena with the command that certain features of industrial life be dealt with directly and comprehensively, both as the means and the substance of instruction. By contrast, manual training centered upon simple tool skill operations of village trades which were largely from nineteenth century Europe. The result is that manual training never was addressed to life in the twentieth century, and, even at its best, that which continues under the name of industrial arts must remain on the periphery of American education.

The Influence of Richards. Dewey had pointed out a radically new approach for the development of schooling in industrial subject matter which was firmly embedded in an educational philosophy that encompassed the whole of American public education. There remained the large task of interpretation and adaptation to an existing subject matter area, manual arts. Charles R. Richards was one of the earliest to take up this task. Professor

Richards was Director of Manual Training at Teachers College, Columbia University. He was also editor of the Manual Training Magazine, and was influential in the professional education associations. His was a strategic position for disseminating the new approach.

Beginning in 1901, in meetings of the National Education Association, in periodicals such as Educational Review and Manual Training Magazine, in speeches to regional and local professional organizations, and certainly in his classes of prospective manual arts teachers, Richards was referring to "content as a reflection of the actual life outside of the school walls, content in its relation to social life," "content as a means of interpreting art and industry," "richer content and more thought material," and "more attention to breadth of information and insight."

These and other ideas were summarized in a 1904 editorial calling for a new name to replace manual training and manual arts. After noting that the disciplinary values implied by the term "manual training" were "psychologically indefensible," he wrote:

> Behind every subject in the curriculum is a body of ideas of fundamental meaning and importance. The industrial arts which stand for one of the most vital and important phases of modern civilization, throw away their claim to recognition by masquerading under a term at once inappropriate and misleading . . .
>
> In the hope of enlisting consideration and discussion, the writer proposes the term suggested above: Industrial Art. Such a term indicates a definite field of subject matter. The word "Art" is inclusive of both technical and aesthetic elements, and the qualifying word points specifically and comprehensively to the special field of our material (Richards, 1904, pp. 32-33).

In 1907, writing in the Manual Training Magazine, Richards pointed out that the progress of the previous 20 years had been chiefly in the area of method. Then he adds, " . . . we have been very slow to admit that our field possesses any subject matter at all . . ." (Richards, 1907, p. 3). He follows this with the challenge:

> Is it not at once our opportunity and responsibility to identify ourselves as the representatives in the school of this great field of human activity and to take for our task as teachers the interpretation of the arts and industries of modern life (Richards, 1907, p. 4)?

Richards' activities were another historical step leading to a modern structuring of subject matter for industrial arts education. In logical argument, he forged a place for the study of industry as a discrete subject at the secondary level. While he never subjected the total content of industry to exhaustive analysis and delineation, he suggested the "elements of industry" in a direction radically different from the "elements" of manual training.

The Influence of Bonser. Meanwhile other voices were being heard, challenging the fundamental tenets of manual training-manual arts. Prominent among them was Frederick G. Bonser, Professor of Education at Teachers College in Columbia University. He has probably been quoted more often than any other in subsequent expressions of justification for industrial arts education. Bonser accepted Dewey's fundamental philosophical groundwork for the study of industry in general education, and went beyond Richards in thought and expression that established industrial arts as a separate and mandatory content field for secondary education.

Secondary industrial educators have quoted him in their statements of theory; school practice of the curriculum area has misinterpreted and misunderstood the full import of his recommendations for industrial study.

As early as 1910, Bonser presented a paper before the faculty of Teachers College, Columbia University, entitled Fundamental Values in Industrial Education. His statements of theory as well as his suggestions for practice were addressed to the unique requirements not only of the elementary grades but of the secondary grades as well. The seeming dichotomy between trade training for occupational ends and the study of industry for liberal education purposes was of major concern to Bonser. He carefully defined and distinguished between "educational value" and "training value." He then stated:

> As a secondary school subject, industrial arts must meet just as fully the test of rich thought content and humanistic values as any other appropriate secondary school subject. . . . Increased knowledge of scientific principles and processes in industrial fields, maturing judgments in interpreting industrial problems and relationships, and growing standards of industrial phases of social life are the elements without which a secondary study of the industrial arts is almost devoid of educational values (Bonser, 1932, pp. 73-74).

There is no mistaking the general characteristics which must mark the learnings resulting from the study of industrial content.

Probably the most frequently cited definition of industrial arts since it appeared in print in 1923 is the following statement:

> The industrial arts are those occupations by which changes are made in the forms of materials to increase their values of human usage. As a subject for educative purposes,

> industrial arts is a study of the changes made by men in forms of materials to increase their value, and of the problems of life related to these changes (Bonser and Mossman, 1925, p. 5).

For all the widespread dissemination which this definition has enjoyed, the full meaning and intent has not been generally understood. The content included in actual practice in the schools has been little more than token recognition of the Dewey-Bonser intent. School practice has tended to overemphasize the basic tool processes and the basic technical information, selecting only that which made a contribution to the school shop project under construction. Much of the practice in the schools never seemed to result in an overall view and understanding of how industry actually produced goods, much less an understanding of the "problems of life related to these changes." The school practice continued to evidence the overwhelming influence of the pressures for developing occupational competency. The treatment of the subject matter has been so direct and structured as to violate most of the criteria for liberalizing study which Dewey and Bonser would have imposed upon educational industrial study.

Bonser spelled out major subdivisions of content, such as the activities to provide food, clothing, and shelter, but he did not develop a complete subject matter structure. His writings, taken collectively, did specify criteria and point out directions so as to establish a trend of development. Had not other forces deterred, subsequent curriculum work might well have followed the Bonser trend and achieved curriculum results that would have satisfied modern requirements for industrial study.

Very early in its life, manual training exhibited a capability for change. Woodward's adamant position notwithstanding, manual training had responded to the best of Swedish Sloyd and the Arts and Crafts Movement. However, during the very period when it should have been making a revolutionary response to Dewey-Richards-Bonser thought (1906-1917), the movement to enlist public support for vocational industrial education was being born, developing, and reaching the maturity of the Smith-Hughes Act. During this period, manual training-manual arts was under fire not only from the Dewey-Richards-Bonser proponents but from the proponents of vocational industrial education as well. The force of manual training-manual arts, pushing in the direction of a predominantly manipulative content, plus what amounted to an ultimatum to conform to the vocational education pressures of the period or face extinction, proved overwhelming. The character of the curriculum area of industrial arts was set in the mold of the Woodward-Runkle tradition with only a token acceptance of the Dewey-inspired line of development. The implementation of the real essence and intent of that movement would need to await a more opportune time.

With full cognizance of the needs and character of modern society and with awareness of the extent and complexity of modern industry, current curriculum efforts in industrial arts education can be regarded as a revival of the spirit of the Dewey-Richards-Bonser approach.

The Influence of Warner. For a decade there was a lull in industrial arts curriculum work of the type conceived by Dewey, Richards, and

Bonser. Also, much of what was done during the entire period from 1930 to 1950 centered around Professor William E. Warner, of The Ohio State University. This is not to ignore the scores of books that have been published under the title of industrial arts, nor to overlook the countless pages of magazine literature and the numerous convention speeches on the same topic. But these, with very few exceptions, stem from and return to the fold of the manual training tradition.

Under the promptings of Dr. Warner, two ideas for developing secondary school industrial arts emerged. The first of these was formulated during the early 1930's and gained attention through a publication, "A Prospectus for Industrial Arts in Ohio" (The State Committee, 1934, p. 101). This was largely a historical and philosophical document that pointed to the source and nature of subject matter. The questions of content and method were directly implied by the physical facility which was termed the Laboratory of Industries.

The Laboratory of Industries was to provide an understanding of the characteristics of industry at the time. Exactly what these characteristics were and just how they might be incorporated into a program of study never became clear. From the very beginning, there was the question of whether industry should be thought of and approached as a totality or in terms of the separate segments of the whole.

The matter was settled for the time being when the teachers adopted such terms as the metal industries, the wood industries, the ceramic industries, etc. to designate the areas of instruction. Having been trained in the manual training tradition, the segmented approach was familiar to practicing teachers and, at the same time, the numerous industries seemed collectively to be much too voluminous to be manageable for instructional purposes.

In passing, it is to be noted that others throughout the nation attempted to use the Laboratory of Industries approach to teaching industrial arts. This gave additional support to wider use of the general shop in one form or another, though generally with subject matter derived from selected skilled trades. There is no evidence, however, that the central problem of postulating or identifying a content universe for industrial arts ever came into focus elsewhere, as it did with Warner's students.

By the end of World War II, it was evident that industry had undergone great transformation in character and potential. Whether for this or some other reason, the time must have been right for a new idea and new terminology to come into industrial arts circles. In April of 1947, Dr. William E. Warner and several graduate students at The Ohio State University took the occasion of the American Industrial Arts Association Convention to present a plan for what they called "a new curriculum for industrial arts." The curriculum, as announced, was to reflect the technology. Reactions to the idea and to the term "technology" were favorable; so much so, in fact, that they soon became common discussion topics when industrial arts groups assembled, and the term has been used with increasing frequency in industrial arts literature.

Reactions to the curriculum plan, on the other hand, have been mixed. Perhaps this was because the proposal was not clear in terms of structure, substance, and application. As an illustration, technology was never defined or even described. At the same time, it was said that content in the new industrial arts curriculum was derived via a socio-economic analysis of the technology. But what was it that was analyzed, and in what way?

The proposal states that the " . . . subject matter classifications are conceived of as including : (a) Power, (b) Transportation, (c) Manufacturing, (d) Construction, (e) Communication, (f) Personnel Management " (Warner, 1961 reprint, p. 6). It is not indicated how or why these classifications came into being. What followed was an ordering of subject matter for these several classifications, which at this point were termed "Divisions." In fact, most of the divisions do not contain subject matter at all. Instead, what was listed were examples of topics in which and by which subject matter might be located.

CONTEMPORARY INDUSTRIAL ARTS CURRICULUM PROPOSALS

Contemporary curriculum work in industrial arts largely has been concerned with educational methodology. While a concern for the organization and selection of content has never been totally lacking in the field of industrial arts, until recently it has not been accorded a relatively high priority. It should be pointed out that this condition has not been unique to industrial arts. The rigid structure of content in subjects such as mathematics, physics, or for that matter even English literature has been widely recognized. Only within the last decade have educators begun to explore the content traditions that have limited elementary and secondary students to Euclidean mathematics, Newtonian physics, and similar restrictive approaches in other subject fields.

Recent efforts to examine the curriculum structure in industrial arts may be grouped into three major categories. These are doctoral dissertations, independently sponsored developmental programs, and substantially supported research and development projects. It is not being suggested here that these efforts have been unrelated to one another, for considerable cross-fertilization within and across these categories is evident. Nevertheless, grouping these curriculum proposals in this manner is justified for purposes of analysis. It also points up important differences in support, scope, sophistication, and resources among the curriculum proposals.

Doctoral Dissertations. Olson's "Technology and Industrial Arts" deserves special attention in any investigation into the evolution of curriculum for industrial arts. It constitutes the vital link between the earlier work of Richards, Bonser, and Warner and that of contemporary theorists and innovators. Basically following a product classification approach, Olson's proposed curriculum accepts (with some modifications) the Census of Manufacturers classification system.

> One of the major problems in arriving at a classification of industries is the establishment of a simplified system

> of grouping with a maximum of consistency within each group and sufficient inclusiveness to be representative. The primary source of industries listings for this study is the Census of Manufacturers and the Annual Survey of Manufacturers (Olson, 1957, p. 3).

For Olson, an understanding of industry (and, consequently, the source of subject matter for industrial arts) derives from a study of technology. It would be well to recall at this point the distinctions previously made between technology and praxiology. Technology, in its common usage, has a restricted meaning, and Olson does not equate it with praxiology.

Eight major categories of industry are identified by Olson, and he states that, "These groups are assumed to account for all American industry that would be essential for curriculum study in industrial arts" (Olson, 1957, p. 95):

(1) Manufacturing

(2) Construction

(3) Power

(4) Transportation

(5) Electronics

(6) Research

(7) Services

(8) Management

Within the manufacturing category, the following industry groups are included:

(a) Ceramics

(b) Chemicals

(c) Foods

(d) Graphic arts

(e) Leather

(f) Metals

(g) Paper

(h) Plastics

(i) Rubber

(j) Textiles

(k) Tools and machines

(l) Woods

Although Olson attempted to identify generalizable conceptual elements which permeate his complete classification structure, the system itself is essentially an amalgam of products (tools and machines), processes (graphic arts), and materials (metal, paper, etc.). It undoubtedly served as a catalytic agent for many of the more recent curriculum proposals; yet it has not received widespread implementation. In part, this is due to its primary focus on categories of industry groups. Practitioners in industrial arts have been unable to envision a workable curriculum pattern providing youth with educational experiences in each of the eight major industry categories. Perhaps additional resistance to the Olson proposal stems from the selection of these eight groups. It has been argued, for example, that management (category 8) and research (category 6) are essential elements in all of the others. Also, electronics (category 5) seems to be of an entirely different order than manufacturing or construction. The Olson proposal does not meet the criteria previously identified for assessing the adequacy of a proposed structure for industrial technology. Not only has it proven to be operationally inadequate for instructional purposes, but its major categories and subcategories are not mutually exclusive.

Bateson and Stern developed and presented the Functions of Industry approach to curriculum in industrial arts (Bateson and Stern, 1963). Industry consists of two major branches: the goods-producing establishments, and the goods-servicing installations. A systematic and sequential classification of activities in the goods-producing branch includes the following major functions:

(1) Fundamental and Applied Research
(2) Product and Process Development
(3) Planning for Production
(4) Manufacturing

The service branch of industry is similarly presented as a set of universal and sequential functions. Regardless of the nature of the malfunction, the following activities are carried on:

(1) Diagnosis of the Malfunction
(2) Correction of the Malfunction
(3) Testing (to determine if the correction has been satisfactorily made)

Sub-functions were identified for each of the major functions, and the complete construct was tested against three basic sources of data outside the field of professional industrial arts. The proposed functions of goods-producing industrial establishments were compared with textbooks in the field of industrial organization, and scrutinized by professional management consultants and personnel from manufacturing establishments. On the basis of these data, the hypothesized functions and their definitions were refined (Stern, 1964).

The Functions of Industry concept has the advantage (from an educational standpoint) of offering a sequential set of organizing concepts through which industrial activities may be more clearly understood. This universal model is not limited as to materials, products, or processes. It applies equally to large or small establishments. Since its primary focus is on conceptual themes, rather than on industry groups, it is more adaptive to technological change.

The two principal shortcomings of the Functions of Industry approach to industrial arts curriculum are the non-recognition of the human factors in industrial technology and the treatment of the goods-servicing installations. With only minor exceptions, this approach is limited to the material aspects of industrial technology. In addition, it poses an artificial separation between goods-producing and goods-servicing economic activities. While this may seem reasonable upon cursory examination (many other classification schemes have made this distinction), closer investigation reveals the many links between these two activities.

Blomgren developed a detailed outline description of American industry in connection with his experimental study (Blomgren, 1962). This outline contains the following four major categories:

I. The Historical Development of American Industry

II. Labor Force and Organization in American Industry

III. Managing American Industry

IV. Technology of Production in American Industry

Each of these major categories contains subcategories, topics, and in some cases, subtopics. The major category, Managing American Industry, for example, includes the following subcategories:

A. The Controlling Philosophy of Management

B. Organization of Management

C. Management and Industrial Efficiency

D. Management and Wage Determination

E. Workers Feelings Toward Work and Management

F. Safety and Health in Industry

In terms of the criteria for an adequate structure of industrial technology, Blomgren's outline has several shortcomings. Important areas are omitted. The entire question of service is overlooked, as are construction and custom manufacturing activities. Within the major categories, a consistent taxonomic structure is not achieved.

Independently Sponsored Developmental Programs. In Alberta, Canada, Ziel has been instrumental in the initiation of a new industrial arts curriculum. The primary focus of this program is on the world of work, including its dominant technologies and its complex social interrelationships. Secondary school industrial arts students advance through four consecutive stages in studying this subject:

Stage I: An introduction to, and appreciation of, the tools, machines, materials, and processes of industry, including activities in woods, metals, ceramics, plastics, graphic arts, and electricity.

Stage II: A study of a number of important contemporary technologies, which include electricity-electronics, computer, mechanical, power, power transmission, graphic communication, and materials and processes testing.

Stage III: A study of the roles of people in productive organizations through simulated organizational experience.

Stage IV: An opportunity for depth studies in clusters of related technologies, e.g., power, power transmission, and mechanical (Ziel, 1962).

In the Ziel plan, industrial arts draws its content from selected technologies. No attempt was made to structure a body of knowledge for the totality of technology. In the absence of such a structure, it might be argued that such criteria as economic importance, representativeness, and expediency may justify the selection being used in Ziel's "world of work" program. Although retaining the name industrial arts for the subject area, the Alberta program includes banking, commerce, and distribution among the productive organizations whose technologies are studied. No attempt is made to clarify the terminological problem where industry and other economic institutions are concerned. Ziel's proposal is particularly strong with regard to practices which affect humans in productive organizations, and the use of simulated industrial experiences may be extremely effective in transmitting to students an understanding of the social dynamics of the world of work. While the existence of common elements has been recognized in the organizational aspects, no attempt has been made to ascertain the existence of generalizable elements in material production practices.

Maley and Keeny have experimented for some years with an industrial arts program based on research and experimentation. In this approach, students engage in applied research activities and draw content from many technological fields. Experiments involving materials testing, strength of adhesives, corrosion, thermal and electrical conductivity, lubricity, and friction are examples of students' work (Maley and Keeny, 1962).

In essence, this program selects a cluster of related technological practices-- research and development--and provides an educational context in which students try out the role of research and development workers. The course content is closely tied to a problem-solving sequence of behaviors. Problem identification, clarification, experimental design, construction of experimental apparatus, data collection, analysis, inferences, and reporting, are the common learnings that permeate the activity. This process-oriented approach to structuring curriculum is similar to that used by other curriculum projects--notably in the physical sciences and in anthropology. The exclusive concern for the practices used in applied research precludes students' exposure to clusters of technological practices that are at least of equal importance. Such omitted areas include broadly conceived management and production practices which provide material goods. The research and experimentation approach similarly overlooks the manifold industrial technology which primarily affects the people in industry.

In addition to the contemporary proposals listed here, there are the independently sponsored proposals by Warner, DeVore, and Yoho, which are described and analyzed in Chapter II, Industrial Arts Curriculum Theorists, page 59. These proposals also are relevant here. They were presented earlier because they relate to an investigation of the nature and scope of technology. They now can be reviewed as they relate to a structure of industry. Note that they each portray industry as being vaster in scope than it is here defined as being. Also, the recommended structures do not present mutually exclusive and totally inclusive categories.

Funded Research and Development Projects. During the last several years, considerable pressure has been generated through public and private agencies to revitalize the curriculum in industrial arts. For the first time, substantial financial support was made available to researchers in this field. Prior efforts to restructure industrial arts have, in the main, been conducted by doctoral candidates fulfilling degree requirements, or by professional educators imbued with the need for reform plus an inspirational concept but without adequate means of support for so massive an undertaking.

The American Industry Project, funded initially by the Ford Foundation, and subsequently by the U. S. Office of Education, is one of the first curriculum projects dealing with industry to receive substantial support. The intent of this project is to identify and develop the major concepts " . . . which directly apply to industry" (Face, et al., 1965, p. 62). While this is the theoretical objective of the project, its operational objectives are:

(1) to develop an understanding of those concepts . . .

(2) to develop the ability to solve problems related . . .

Industry is defined " . . . as a complex of organizations that utilizes the basic resources of men, materials, machines, and money to produce goods or provide services to meet the needs of man" (Face, et al., 1965, p. 64). It is the intent of the project to provide a new school program to be known as "American Industry." However, it is so similar in purpose to industrial arts that it must be reviewed here.

The major concepts which form the structure of American Industry are:

1. communication
2. energy

3. processes
4. materials
5. production
6. management
7. marketing
8. personnel, public, and industrial relations
9. purchasing
10. research and development
11. physical facilities
12. financing
13. public interest
14. transportation

Each of these major concepts is being further refined to yield more specific sub-concepts, until the smallest unit, a minor concept, is reached. In this manner, for example, "fastening" is a sub-concept within the major concept "processes." "Adhesion" is a more specific sub-concept of "fastening," and "brazing" and "gluing" are further refinements within the sub-concept of "adhesion."

The conceptual approach attempts to focus on the universal features of American industry. " . . . understandings of concepts derived from this structure would be universally applicable in any specific industry which encompasses it." It is stated that conceptual learning enhances " . . . retention, transfer, and application of knowledge to new and different situations" (Face, et al., 1965, p. 65).

The major difficulty involved in the American Industry Project lies in the identification of the relevant major concepts. By definition, industry is equated with the entire economic system. However, the fourteen major concepts fail to meet the criterion of inclusiveness. For example, agriculture, entertainment, and personal services are omitted at this level. According to the criterion of mutual exclusiveness, there are also apparent inadequacies. For example, "purchasing" seems to involve "physical facilities" and "materials," while "public interest," "communications," and "public relations" are not mutually exclusive.

Teachers in all subject areas have long been aware of the educational advantages of focusing on generalizable concepts rather than on discrete increments of fact. The central questions are: "Which concepts?"; "In what sequence should they be taught?"; and "Do they collectively present a holistic, unified view of the societal institution of industry?". In view of the above, these questions continue to plague the American Industry Project.

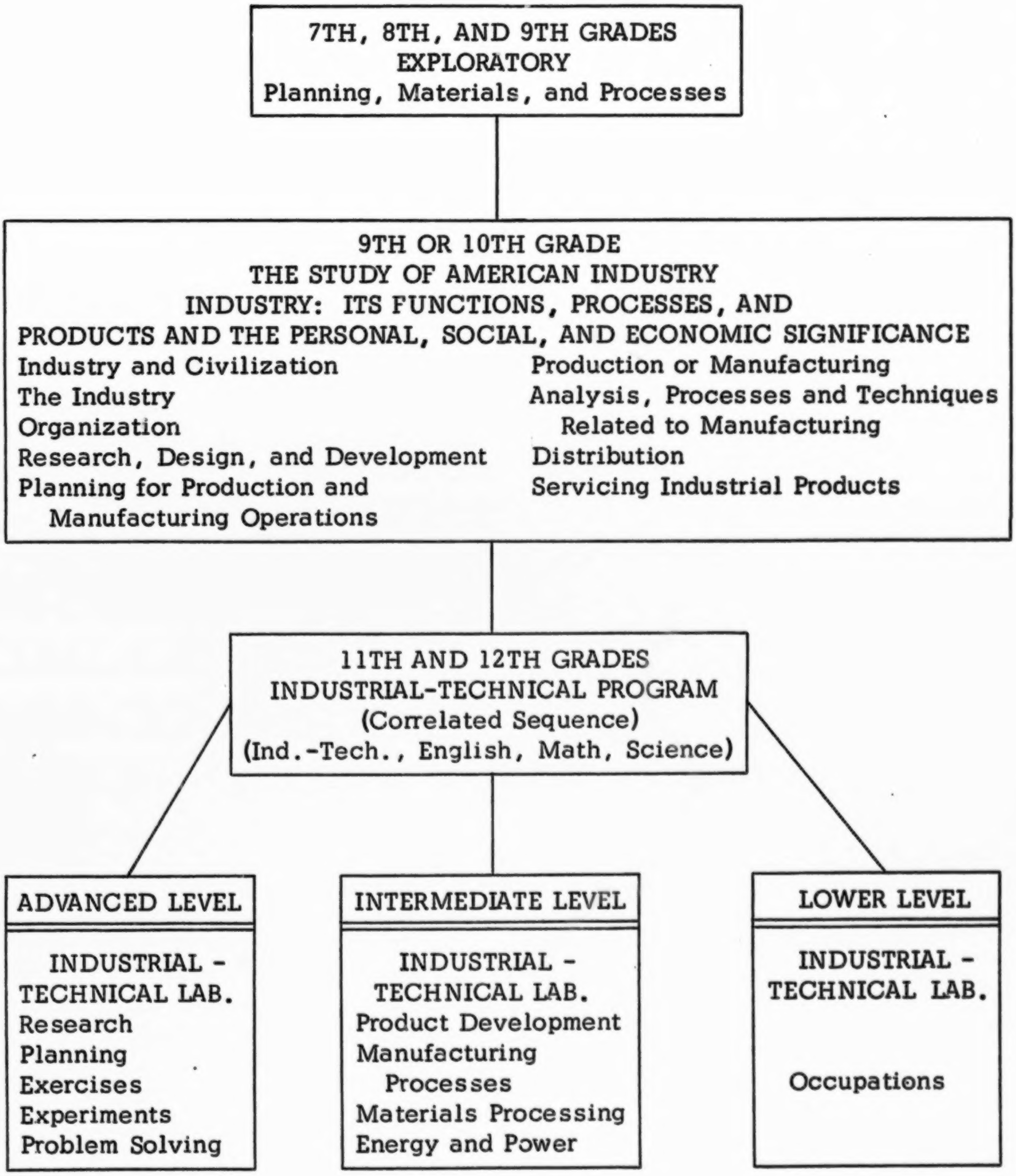
Minelli has initiated the Partnership Vocational Education Project in recognition of the inter-institutional relationships that influence a comprehensive attempt to restructure curriculum in industrial-technical education (Central Michigan University, 1965). A tentative curriculum structure is being developed for grades 7-12 with the participation of partnership community colleges, technical institutes, and Central Michigan University. The unique longitudinal feature of this program would permit a student to select from a number of alternative career paths related to industrial technology. His occupational choice would be built upon progressive and related educational experiences moving from exploratory in the 7th, 8th, and 9th grades, toward increasing specificity at the community college or university levels. Implicit in this program is an effort to avoid educational patterns that lead to a "dead-end" in the world of work.

The proposed curriculum in industrial-technical education for participating schools is depicted in Figure XIII. It will be noted that the exploratory phase (grades 7, 8, and 9) is to deal with "Planning, Materials, and Processes." This outline, and other materials available to date, do not indicate the specific content. The Study of American Industry is the central theme at the 9th or 10th grade level. A number of major topics are proposed at this level, e.g., The Industry, Research, Design and Development, and Distribution. In the 11th and 12th grades, participating students will move to a more specific prevocational track, based essentially on ability levels. It should be added that transfer from one track to another would not be precluded. In terms of educational methodology, interdisciplinary curriculum planning and extensive utilization of team teaching are anticipated. In addition, recent innovations in educational technology such as television, electronic tape, and teaching machines will be incorporated.

While the Partnership Vocational Education Project is still in its early stages of development, some pertinent observations may be made.

Figure XIII

THE PARTNERSHIP VOCATIONAL EDUCATION PROJECT CURRICULUM FOR INDUSTRIAL-TECHNICAL EDUCATION FOR PARTICIPATING SCHOOLS


7TH, 8TH, AND 9TH GRADES
EXPLORATORY
Planning, Materials, and Processes
9TH OR 10TH GRADE
THE STUDY OF AMERICAN INDUSTRY
INDUSTRY: ITS FUNCTIONS, PROCESSES, AND PRODUCTS AND THE PERSONAL, SOCIAL, AND ECONOMIC SIGNIFICANCE
Industry and Civilization
The Industry
Organization
Research, Design, and Development
Planning for Production and Manufacturing Operations
Production or Manufacturing
Analysis, Processes and Techniques Related to Manufacturing
Distribution
Servicing Industrial Products
11TH AND 12TH GRADES
INDUSTRIAL-TECHNICAL PROGRAM
(Correlated Sequence)
(Ind.-Tech., English, Math, Science)
ADVANCED LEVEL
INDUSTRIAL - TECHNICAL LAB.
Research
Planning
Exercises
Experiments
Problem Solving
INTERMEDIATE LEVEL
INDUSTRIAL - TECHNICAL LAB.
Product Development
Manufacturing Processes
Materials Processing
Energy and Power
LOWER LEVEL
INDUSTRIAL - TECHNICAL LAB.
Occupations

The proposed program is massive in scope and complex in interlocking institutional relationships. The identification of appropriate units of instruction for the participating secondary schools is a huge undertaking. In addition to the size of this task, a carefully developed conceptual model or theoretical framework will be needed to build the syllabi and instructional units to achieve a satisfactory level of synthesis and integration. Were the body of knowledge for industrial technology already well organized and codified, perhaps the goals of the Partnership Vocational Education Project could be more fully realized.

The American Institutes for Research (A.I.R.) has been conducting a number of curriculum projects specifically related to vocational-technical education (Altman, 1965). Project ABLE, for example, involving the City of Quincy, Massachusetts, is designed to develop a new vocational-technical curriculum. Toward this end, representative jobs within the following eleven job families are being analyzed:

1. Electro-electronics
2. Metals and machines
3. Power mechanics
4. General woodworking
5. General piping
6. Foods preparation
7. Computer data processing
8. Health occupations
9. Graphic and commercial arts
10. Home economics
11. Business education

An analysis of these eleven job families reveals the omission of many other categories in total economic activity. In addition, the categories are not mutually exclusive. For example, "Computer data processing" is increasingly a part of "Business education," and "Home economics" includes "Foods preparation."

The General Vocational Capabilities Project is being conducted by A.I.R. to identify basic vocational skills and knowledges that might have educational implications. The tasks involved in thirty-one jobs were analyzed, a random selection from these tasks was translated into test items, and these tasks in turn were administered to about 10,000 students from the ninth grade through junior college. Essentially, six capability areas--mechanical, electrical, spatial, chemical and biological, symbolic, and people--were intercorrelated and placed on a continuum from hardware-oriented to people-oriented. Mechanical Systems, Tools, and Fluid Systems exemplify the hardware orientation; while Garment Equipment Operation, Foods and Cooking, and Style and Grooming typify the people orientation.

Out of these analyses grew a statement of major objectives for an integrated vocational curriculum geared to the high school, the junior high school, and the grammar (sic) school (Altman, 1965, p. 11). The principal components for these programs are Society and Work, Occupational Information, Self-Knowledge, Career Planning, Basic Technology, and Specific Vocational (Altman, 1965, pp. 12-13). One of these--Basic Technology--is further delineated in Figure XIV.

Figure XIV

PRINCIPAL COMPONENTS OF BASIC TECHNOLOGY

General Work Habits

This area of the curriculum would include a delineation of effective job behaviors having application to almost all but the most elementary jobs. It would include information concerning work scheduling, standards, and decision-making.

Machines and Mechanical Principles

This area of the curriculum would organize information about mechanical components and principles applied in a wide variety of industrial and home situations.

Electrical Principles

This area of the curriculum would include concepts and principles of electricity, electro-mechanics, and electronics which are commonly applied in work and home situations.

Structures

This area of the curriculum would include the application of geometry and elementary drawing techniques to problems of simple structural design and representation.

Chemical and Biological Principles

This area of the curriculum would include the application of elementary concepts and principles of chemistry, biology, and radiation physics to common problems found in a variety of occupations.

Numerical Operations

This area of the curriculum would provide practice on a variety of numerical problems commonly required on jobs.

Verbal Communication

This area of the curriculum would emphasize practice on aspects of spoken and written English which are commonly important to jobs.

Human Relations

This area of the curriculum would cover the aspects of human interaction frequently encountered in jobs.

The work of the American Institutes for Research, briefly reviewed here, seems to be systematic, fundamental, and methodologically sound. However, thirty-one "jobs" out of approximately 35,000 job titles listed in the Dictionary of Occupational Titles seems to be a small sample, since the study purports to identify General Vocational Capabilities. Interestingly enough, as reported elsewhere in this paper, the most recent work of the Department of Labor identified three major categories of worker functions: things (hardware), data, and people (see Figure XVI, page 131). To be truly comprehensive, it would appear that A.I.R.'s research should sample the entire world of work, or else it risks omitting economically-significant areas of employment. Job and task analysis, even when combined with sophisticated statistical techniques, may not necessarily result in an adequate structure for vocational or technological education (see Systems of Industrial Classification, Occupations, page 130).

Compared with the research and development projects previously reviewed in this section, "The Richmond Plan" is directed toward a rather narrow band in the occupational spectrum. Financed by a grant from The Rosenberg Foundation of San Francisco (and subsequently by The Ford Foundation), and implemented in Richmond, California, this new curriculum approach is specifically designed " . . . to prepare capable average college prep students for a two-year technical institute program in public or private junior colleges" (The Richmond Plan, 1962, p. 15). This Pre-Technician Preparatory Program attempts to provide a smooth transition into specialized post-high school technical programs. Industry's growing need for engineering aides and technicians has resulted in the rapid growth of the two-year technical program, particularly on the West coast. The "Richmond Plan" provides a unique, integrated approach for students who have made this particular occupational choice.

The program is structured around the engineering sciences, with mathematics, tech lab-drafting, and English being integrated through learning experiences relating to the electrical, mechanical, and chemical technologies. The relationships among these subjects are depicted in the Project Flow Chart, Figure XV (The Richmond Plan, 1962, p. 53a). At the eleventh grade level, the key course is physics, and the activities are closely related to the following units:

1. Measurement of Physical Phenomena
2. Theory of Machines
3. Mechanics
4. Sound and Wave Motion

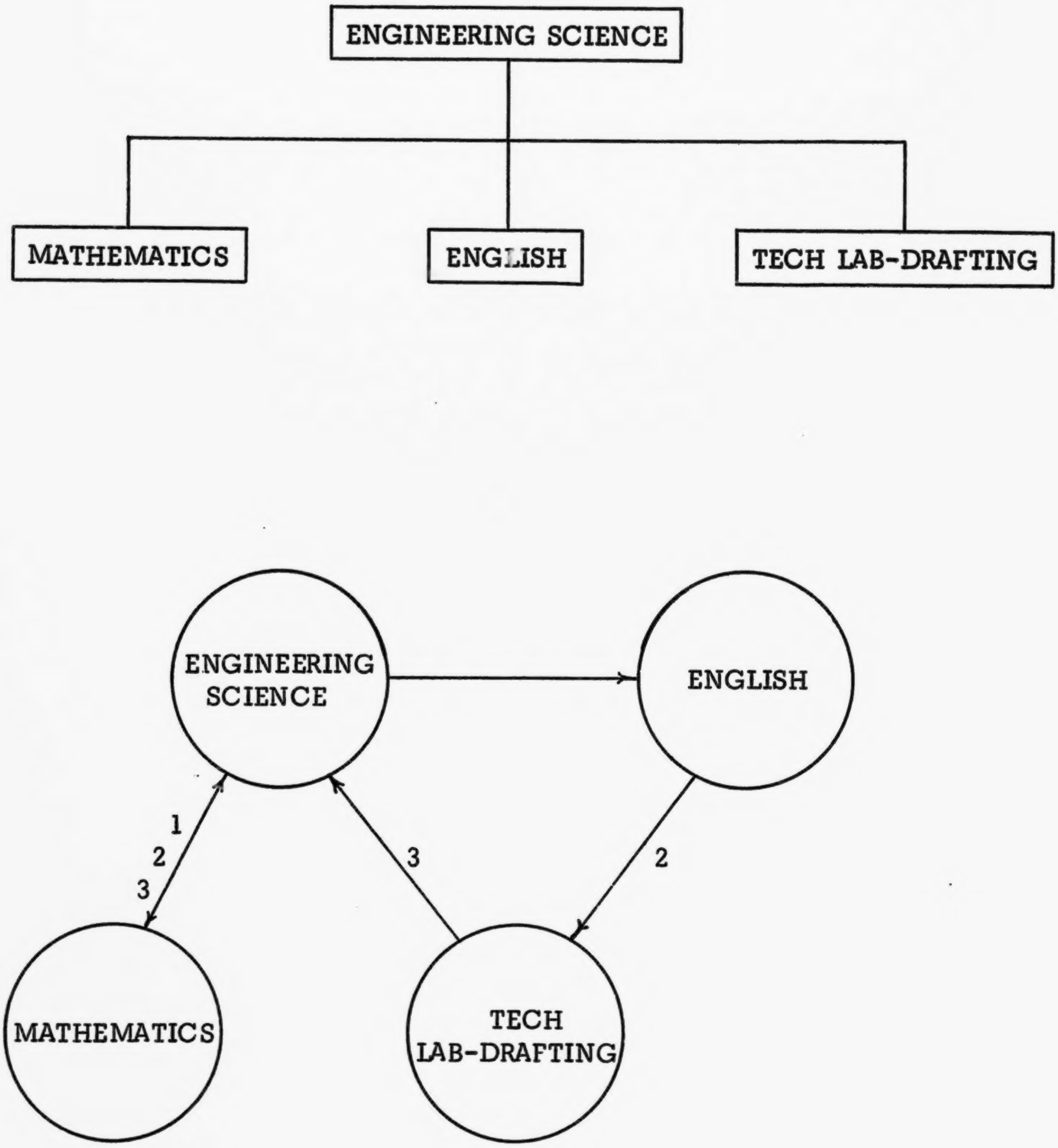
During the twelfth grade, physics and chemistry are the focal points of the curriculum. Units in Sound, Electricity, Atomic-Molecular Theory, The Chemistry of Solutions, Metals, etc., typify the instructional content of the science program, while appropriate correlations in mathematics, English, and tech-lab complete the integration.

It is clear that the "Richmond Plan" is not based upon a structure for the body of knowledge relevant to industrial technology. Assuming that the student has chosen a technician level occupation, and that this is an

Figure XV

THE RICHMOND PLAN

PROJECT FLOW CHART


ENGINEERING SCIENCE
MATHEMATICS
ENGLISH
TECH LAB-DRAFTING
ENGINEERING SCIENCE
ENGLISH
1
2
3
3
2
MATHEMATICS
TECH LAB-DRAFTING

appropriate choice, the Pre-Technology program provides an integrated applied science background calculated to facilitate entry into, and progress through, a post-high school technical program. More specifically, the "Richmond Plan" provides access only into those technical occupations which are based upon physics or chemistry. No provision is made for those who would pursue technical careers based on the life sciences or, for that matter, those whose career plans are more technologically than scientifically oriented.

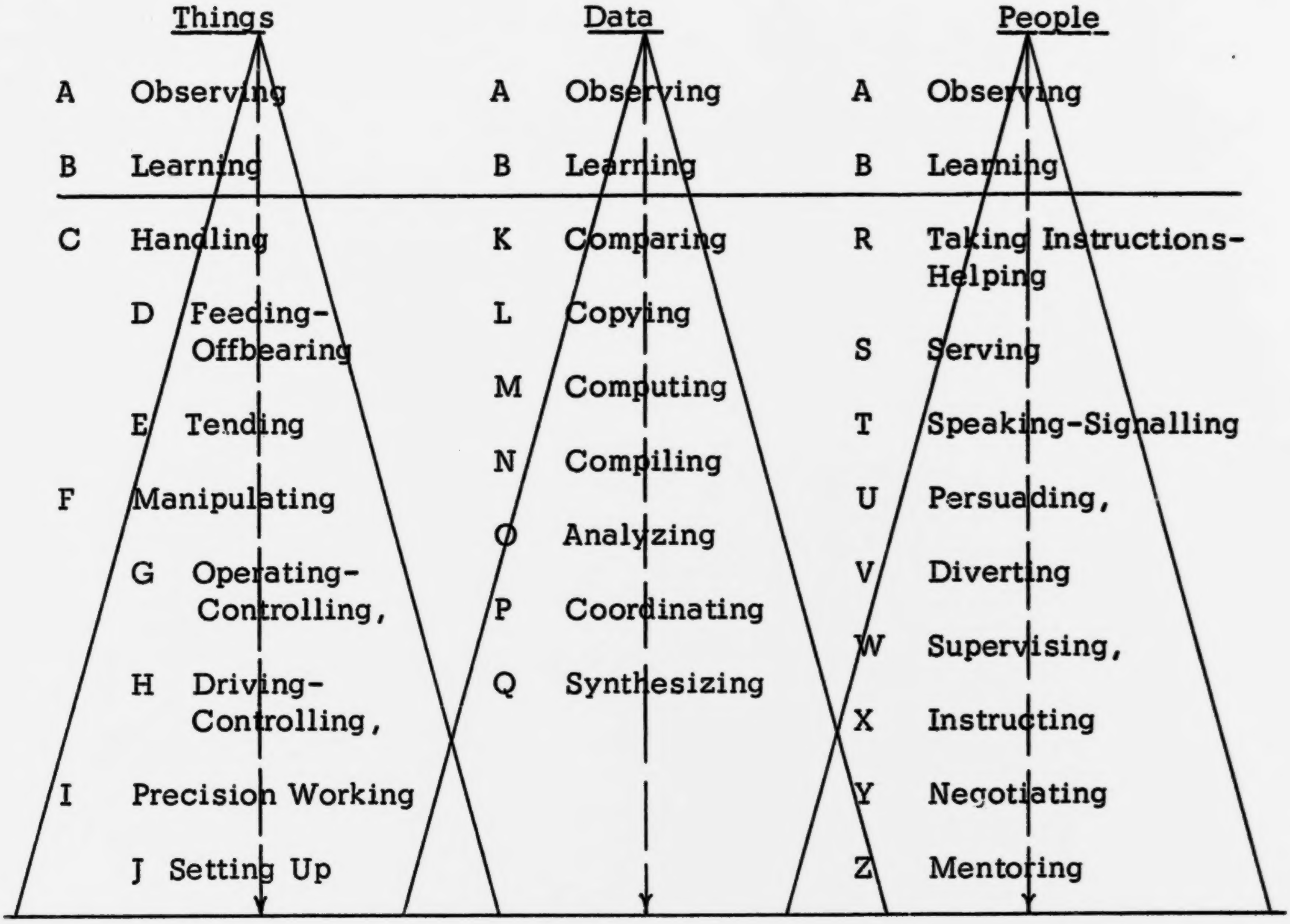
SYSTEMS OF INDUSTRIAL CLASSIFICATION

The four principal bases which have been used for industrial classification are: (1) occupations, (2) processes, (3) products, and (4) materials. Each of these has been used and developed for various purposes by governmental and private agencies.

Occupations. Industrial classification by occupation has been a major concern of the U. S. Department of Labor. Its Dictionary of Occupational Titles, together with the supplementary handbook listing families of occupations, has been a basic work in vocational guidance, employment surveys, and manpower research and training (U. S. Department of Labor, Third Ed., 1965). Its Work Performed Manual (U. S. Department of Labor, 1959) has offered a new approach to classifying occupations. A "Structure of Worker Functions" has been developed, listing nineteen action verbs which relate the worker to "things," "data," and "people." This structure appears in Figure XVI. It is hoped that this new system of classification

Figure XVI

STRUCTURE OF WORKER FUNCTIONS



Things	Data	People
A Observing	A Observing	A Observing
B Learning	B Learning	B Learning
C Handling	K Comparing	R Taking Instructions-Helping
D Feeding-Offbearing	L Copying	
		S Serving
	M Computing	
E Tending		T Speaking-Signalling
	N Compiling	
F Manipulating		U Persuading,
	O Analyzing	
G Operating-Controlling,		V Diverting
	P Coordinating	
		W Supervising,
H Driving-Controlling,	Q Synthesizing	
		X Instructing
I Precision Working		Y Negotiating
J Setting Up		Z Mentoring

Notes:

1. Each successive function reading down usually or typically includes all those that precede it.

2. Feeding-Offbearing and Tending, Operating-Controlling and Driving-Controlling, and Setting Up are special cases involving machines and equipment of Handling, Manipulating, and Precision Working, respectively, and hence are indented under them.

3. The hyphenated factors Feeding-Offbearing, Operating-Controlling, Driving-Controlling, Taking Instructions-Helping and Speaking-Signalling are single functions.

4. The factors separated by a comma are separate functions on the same level separately defined. They are on the same level because although excluded from the one above it, usually one or the other and not both are included in the one below.

will provide labor market analysts and employment and vocational education personnel with a more satisfactory tool than the original Dictionary of Occupational Titles.

The proposed "Structure of Worker Functions" may in fact include all industrial practices and have mutually exclusive subcategories. While these criteria of an adequate structure may be adequately accommodated, the criterion of suitability must be carefully examined. The "Structure of Worker Functions" approach of the Department of Labor is not an appropriate system of industrial classification for educational purposes. Without a substantive context or mold into which to cast them, abstractions such as "observing," "handling," "manipulating," or "synthesizing" will not convey to students a clear understanding of industrial practices. While they may constitute a hierarchical structure of activities performed in industry (among other institutions), Worker Functions do not (individually or collectively) project an adequate taxonomic view of the institution.

Processes. As the Department of Labor and others have grappled with the problems involved in classifying industrial activities by occupations, efforts have been under way to classify industry by fundamental processes. In the main, these attempts have generally been weighted in the direction of the manufacturing industries. Although several such systems of classification were reviewed, two seemed particularly promising.

The American Society of Tool and Manufacturing Engineers, concerned with the growing complexity of manufacturing industry and anxious to provide more adequate and efficient service to its members, has recently undertaken to organize nine major technical divisions. These are:

1. assembly
2. casting, molding and metallurgical processing
3. engineering materials
4. finishing and coating
5. inspection and quality control
6. manufacturing management
7. manufacturing systems
8. material forming
9. material removal

The membership of the Society will be grouped within these divisions; technical information will be classified and disseminated along these lines; and meetings of the organization will be structured within this framework (Appendix G).

With the exception of the Engineering Materials Division, the ASTME classification system is wholly process-oriented. Minor incongruities are likely to occur in any system of classification. The Technical Division system is not without such problems, yet it may very well perform the function for which the Society developed it. From the point of view of a structure of industrial technology for educational purposes, it has two primary shortcomings. Both of these relate to the criterion of inclusiveness:

1. The ASTME Technical Divisions do not adequately represent several major industry groups. Among

these are the utilities industries, the chemical process industries, and the entire construction sector.

2. While the proposed structure may be entirely consistent with the purposes and membership of the Society, it represents, at best, only a part of industrial technology.

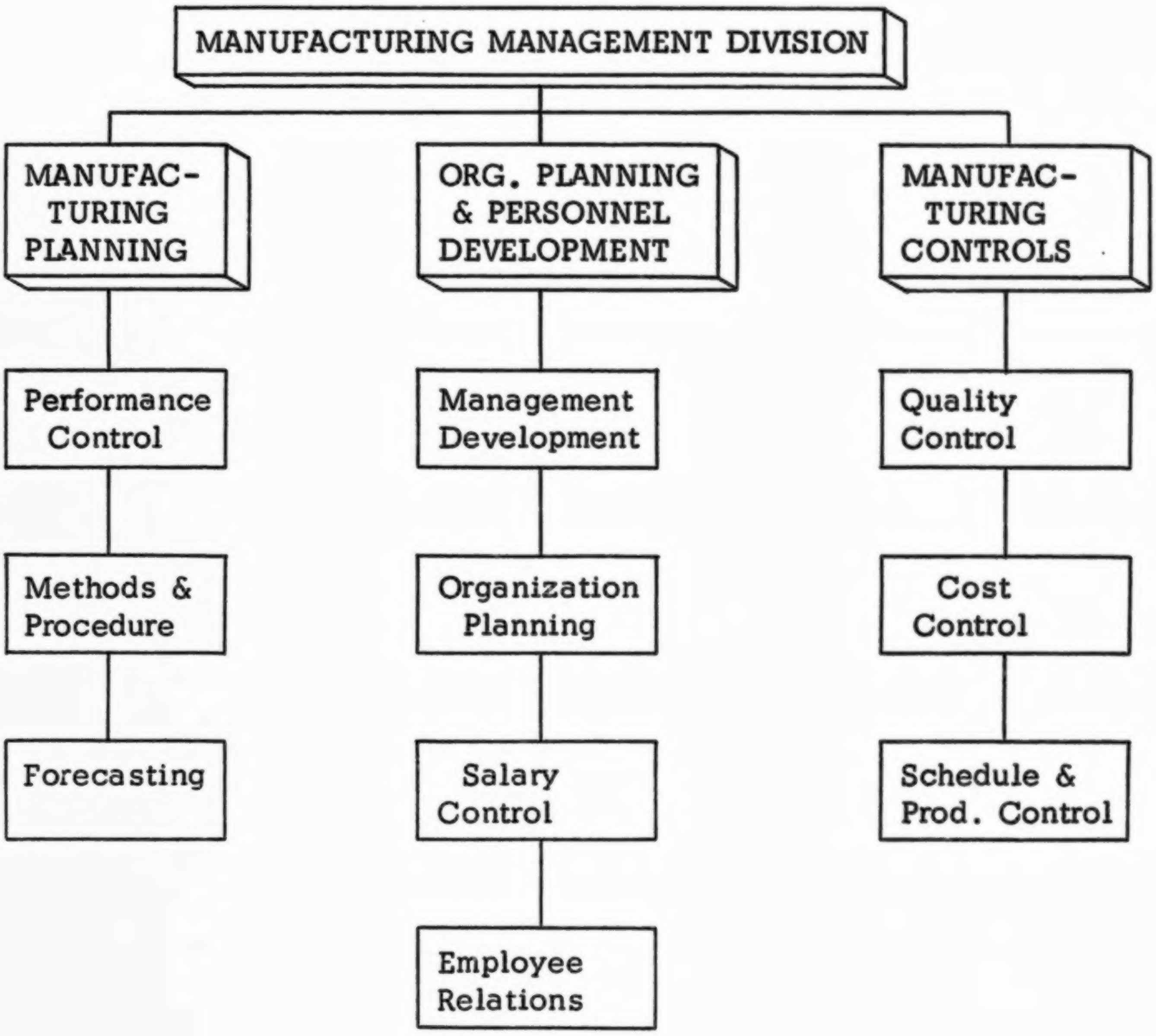
Further, this approach does not adequately provide for those industrial practices which primarily affect humans. The Manufacturing Management Division will (through its subdivision Organization, Planning, and Development) concern itself with management development, organization planning, salary control, and employee relations (Figure XVII). The human aspects of industrial technology, however, include other dimensions that are of major importance. The structure should in some manner provide for consideration of the human aspects. In this regard, the disciplines of industrial sociology, labor economics, industrial psychology, industrial anthropology, and industrial history may be as relevant as industrial engineering or industrial management.

The second process approach to industrial classification that will be examined is the Unit Operations Analysis scheme of Arthur D. Little, Inc., an industrial research organization. Originally developed as a comprehensive classification system for activities carried on in the chemical process industries, Unit Operations Analysis has recently been expanded

Figure XVII

PRELIMINARY ORGANIZATION CHART

AMERICAN SOCIETY OF TOOL AND MANUFACTURING ENGINEERS


MANUFACTURING MANAGEMENT DIVISION
MANUFACTURING PLANNING
ORG. PLANNING & PERSONNEL DEVELOPMENT
MANUFACTURING CONTROLS
Performance Control
Methods & Procedure
Forecasting
Management Development
Organization Planning
Salary Control
Employee Relations
Quality Control
Cost Control
Schedule & Prod. Control

to embrace " . . .all manufacturing and information processing industries." In fact, the researchers who have developed this concept feel that " . . . the unit operations concept and the list of operations are applicable to other industries, e.g., forestry, farming, service, etc." (Arthur D. Little, Inc., 1965, p. 9).

Ninety-four unit operations have been identified and defined (Appendix H). These operations are limited to processes involving information and materials. The major categories under which they are classified are:

1. Record System Unit Operations
2. Unit Operations in the Process Industries
3. Materials Handling Operations
4. Forming Operations
5. Material Removing Operations
6. Further Miscellaneous Operations
7. Fastening Operations

Typical unit operations within these categories are: selection, transmission, and interpretation in the Record System category; crystallization, flotation, and centrifugation in the Process Industries category; and casting, forging, and stamping in the Forming category.

The Arthur D. Little concept for classifying industrial processes is a serious and worthwhile attempt to develop a general and comprehensive classification system that may be applied to all industrial activities regardless of product, process, or size of establishment. There are minor tensions within the structure, but the major shortcoming is the total absence of the human dimensions of industrial technology. This is understandable. The purpose for which the classification was developed was to identify those process elements intrinsic to industrial operation, irrespective of man's transitory role in their performance. While Unit Operations Analysis may be extremely helpful in structuring industrial practices which primarily affect materials, it makes no provision for those industrial practices which primarily affect humans.

Products/Materials. Four of the more common product-based industrial classification systems are summarized in Figure XVIII. Typical major categories within these systems are agriculture, mining, manufacturing, construction, transportation, communication, utilities, and services.

A specialized refinement from these classification systems is the Leontief approach to inter-industry economic analysis (Leontief, 1965). The major purpose of this analytical tool is the prediction of the impact on the total economy of changes in demand or output of any specific industry group. An increase in the demand for automobiles has a quantitative and calculable effect on the basic steel industry, which in turn has an effect on the rolling mill machinery industry, which has an effect on the machine tool industry, and so on, a chain reaction through the entire economy. Leontief's structure consists of an 81 x 81 matrix of goods and service producers. Within the structure, the following major categories are identified:

A. Final non-metal

Figure XVIII

PRODUCT-BASED INDUSTRIAL CLASSIFICATION SYSTEMS

International Standard[1]	Industrial Outlook[2]	Standard Industrial[3]	Classified Index[4]
Agriculture, Forestry, Fishing & Hunting	Agriculture	Agriculture, Forestry, & Fishing	Agriculture, Forestry, & Fishing
Mining & Quarrying	Mining	Mining	Mining
Manufacturing	Manufacturing	Manufacturing	Manufacturing
Construction	Contract Construction	Contract Construction	Construction
Transport, Storage & Communication	Transportation	Transportation, Commun., Electric, Gas, & Sanitary Servs.	Transportation, Commun., & Public Utilities
	Communications		
Electricity, Gas, Water & San. Services	Public Utilities		
Commerce	Wholesale & Retail Trade	Wholesale & Retail Trade	Wholesale & Retail Trade
Services	Services	Services	Services: Bus. & Repair, Personal, Entertainment & Rec., Prof. & Related
Activities Not Adequately Described	Others	Non-Classified Establishments	
	Finance, Ins. & Real Estate	Finance, Ins. & Real Estate	Finance, Ins. & Real Estate
	Government	Government	Pub. Admin.

[1] Indexes to the International Standard Industrial Classification of All Economic Activities, United Nations, New York, 1959.

[2] U. S. Industrial Outlook, U. S. Department of Commerce, 1964.

[3] Standard Industrial Classification Manual, U. S. Technical Committee on Industrial Classification, U. S. Government Printing Office, 1957.

[4] Classified Index of Occupations and Industry, U. S. Department of Commerce, 1964.

B. Final metal

C. Basic metal

D. Basic non-metal

E. Energy

F. Services

Although the complete classification of these 81 industry groups is shown in Appendix I, a sample at this point will reveal the nature of the inter-industry structure.

A. Final Non-Metal

1. footwear and leather products
2. miscellaneous furniture and fixtures
3. household furniture
4. tobacco manufactures
5. apparel
6. miscellaneous fabricated textile products
7. drugs, cleaning and toilet preparations
8. food and kindred products

While the major categories in the system are materials-oriented (basic metal, final non-metal, etc.), the subsets within these categories are uniformly product-centered. This classification system shows numerous exceptions to the criterion of exclusiveness; nevertheless, it may satisfy the purpose for which it was conceived, i. e., economic prediction. As a structure for the body of knowledge in industrial technology, however, it (along with other product-based systems) must be rejected as being unsuitable. The basis for classification--the product--does not provide a conceptual vehicle for industrial technology.

AN ANALYSIS OF CONTENT STRUCTURE OF CONTEMPORARY NATIONAL CURRICULUM PROJECTS

Contemporary curriculum projects in other disciplines may be examined from many standpoints. The selected method of analyzing curriculum projects was to examine the content structures utilized. A review of materials developed by twenty curriculum projects (see Appendix J) resulted in the following analysis.

First, some projects advocate the selection of basically new content for their subject field and others do not. A number of successful projects have focused almost exclusively upon the preparation and dissemination of superior instructional materials. Implicit in this practice is an acceptance of existing content and, presumably, the criteria by which it was selected. The chief task undertaken by these curriculum workers was that of improving instruction by providing teachers and students with materials that communicate and motivate more effectively than those used previously. The Elementary School Science Project (ESSP) and the Elementary Science Study (ESS) typify curriculum projects with principal emphasis in the direction of improved educational methodology.

Content modification has largely followed two paths, with some important projects incorporating features from both. These two curriculum change paths are:

1. changes that reflect a non-traditional way of looking at the substantive matter in the related disciplines, and
2. changes that reflect the procedures used by professional workers in the related disciplines.

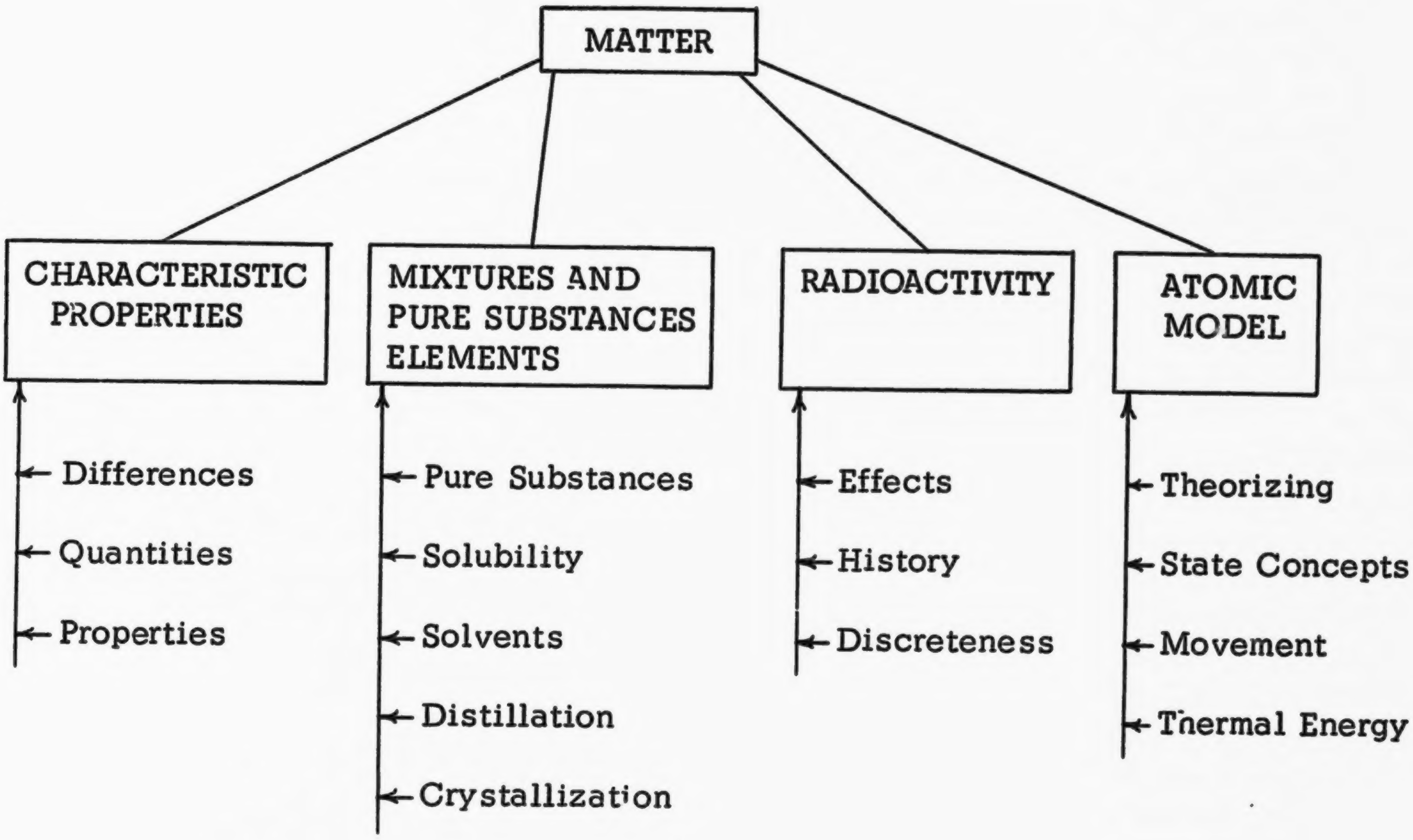
These are referred to here as substantive changes in the subject matter structure and process-oriented changes, respectively. An example of the substantive approach is the Physical Science Study Committee (PSSC) which combined concepts from physics and chemistry. Not only did it combine two disciplines (from the descriptive realm of knowledge), but it broke away from the traditional substantive structure that had previously been used in schools. Physics had for many years been taught through such units as heat, light, and mechanics. Chemistry, likewise, was structured around mixtures, compounds, and the periodic table of elements. The substantive structure advanced by PSSC is depicted in Figure XIX.

While the PSSC content represents a substantive change from tradition, the teaching strategy represents a process-oriented change. In addition, PSSC did not attempt to restructure the knowledge in the related disciplines; its primary purpose was the replacement of the traditional subject matter structure in the secondary school. This implies a basic satisfaction with the existing structure for the body of knowledge and a dissatisfaction with the subject matter structure.

An example of the process-oriented approach to curriculum change is the American Association for the Advancement of Science's Science -

Figure XIX

CURRICULUM STRUCTURE ADVANCED BY THE PHYSICAL SCIENCE STUDY COMMITTEE


MATTER
CHARACTERISTIC PROPERTIES
Differences
Quantities
Properties
MIXTURES AND PURE SUBSTANCES ELEMENTS
Pure Substances
Solubility
Solvents
Distillation
Crystallization
RADIOACTIVITY
Effects
History
Discreteness
ATOMIC MODEL
Theorizing
State Concepts
Movement
Thermal Energy

A Process Approach curriculum project. The structure of this program is based upon (1) elements of commonality among the sciences, and (2) skills and procedural operations. This program is not specifically related to the recognized disciplines of science *per se*. The following list of basic skills indicates the process-oriented approach:

1. Observation
2. Classification
3. Measurement
4. Quantification
5. Communication
6. Organizing through space and time
7. Inferences and predictions

The Anthropology Curriculum Study Project (ASCP) follows a similar orientation. In the substantive sense, emphasis is directed at:

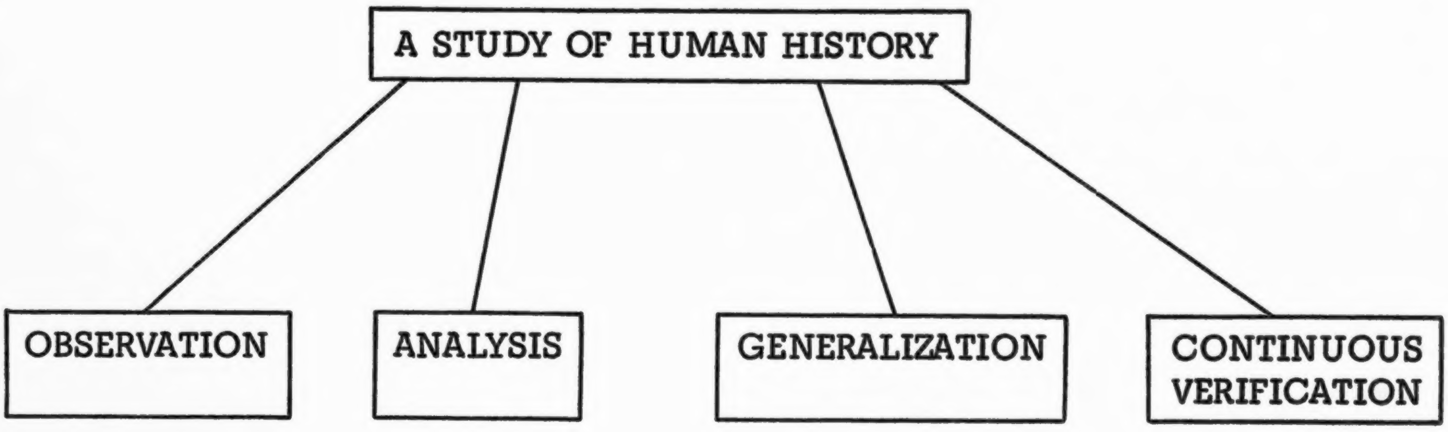
1. Man's complex bio-cultural history
2. His contemporary cultural and physical varieties

The process-oriented approach is depicted in Figure XX.

Among those curriculum projects advocating substantive changes in the structure of subject matter, there is a broad range in degree. While some projects limited their efforts to relatively few substantive changes, others recommended a complete restructuring of the subject matter. The Earth Science Curriculum Project (ESCP), for example, drew from its related disciplines of geology, astronomy, oceanography, meteorology, petrology,

Figure XX

THE PROCESS-ORIENTED APPROACH OF THE ANTHROPOLOGY CURRICULUM STUDY PROJECT


A STUDY OF HUMAN HISTORY
OBSERVATION
ANALYSIS
GENERALIZATION
CONTINUOUS VERIFICATION

and physical geography to advance the substantive and process-oriented structure which appears in Figure XXI.

Of the twenty curriculum projects reviewed, only two attempted to restructure their body of knowledge. They are the School Health Education Study (SHES) and the Organic Curriculum-Economic Education (OCCE). The proposed structure for the body of knowledge appropriate for health education is contained in Appendix K. The conceptual model for the body of knowledge in economic education is contained in Appendix L.

A distinction also should be made among the curriculum projects considered in this review with respect to their related disciplines. The following types are identified:

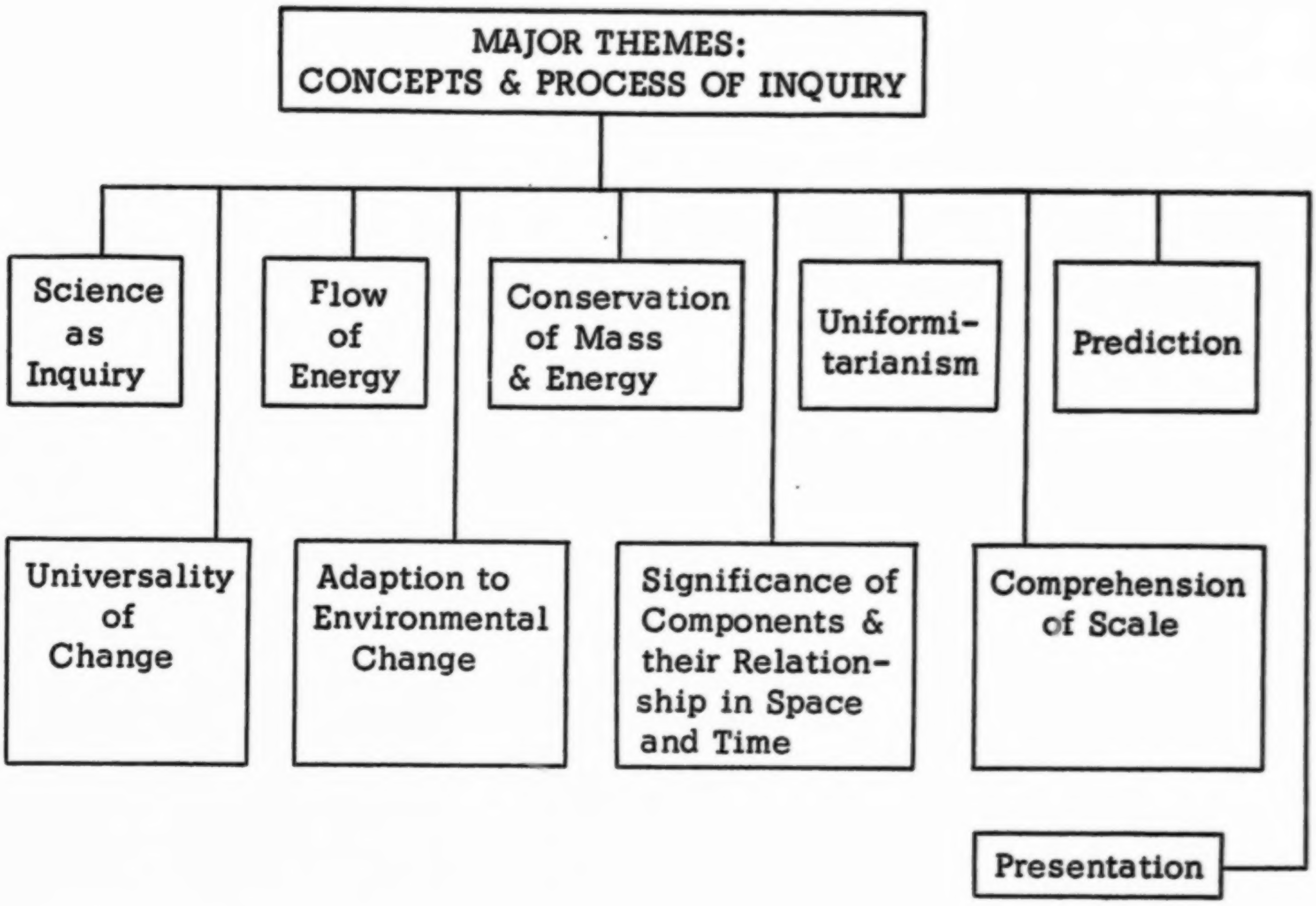
1. Curriculum projects drawing their subject matter from a single discipline.
2. Curriculum projects drawing their subject matter from several disciplines.

Examples of those in the first category are the University of Illinois Committee on School Mathematics (UICSM), the World History Project (WHP), and the Chemical Bond Approach (CBA).

Projects which derive their subject matter from several disciplines may draw from disciplines in one realm of knowledge or from disciplines in two or more realms of knowledge. ESCP and PSSC each are based upon two or more disciplines from the descriptive realm of knowledge, and the Engineering Concepts Curriculum Project (ECCP) draws its content essentially

Figure XXI

SUBJECT MATTER STRUCTURE PROPOSED BY THE EARTH SCIENCE CURRICULUM PROJECT


MAJOR THEMES:
CONCEPTS & PROCESS OF INQUIRY
Science as Inquiry
Flow of Energy
Conservation of Mass & Energy
Uniformitarianism
Prediction
Universality of Change
Adaption to Environmental Change
Significance of Components & their Relationship in Space and Time
Comprehension of Scale
Presentation

from several disciplines in the technological realm of knowledge. On the other hand, the SHES and OCEE curriculum projects draw their subject matter from not only several disciplines but from disciplines in several realms of knowledge. In the case of SHES, these are personal hygiene, public health, and dietetics (technological disciplines), as well as physiology, anatomy, and sociology (descriptive disciplines). The conceptual model of OCEE indicates that disciplines from the technological, descriptive, and prescriptive realms are heavily involved in economic knowledge.

Finally, it should be noted that SHES was the only curriculum project that developed a multi-dimensional structure for the necessary body of knowledge, including physical, mental, and social dimensions. These three dimensions of health permeate each of the hierarchical levels of their structure.

This analysis has reported some of the important typologies in contemporary curriculum work. On a continuum of task complexity, it is apparent that the range is enormous. While some projects concentrate on educational methodology, others have undertaken to restructure the subject matter, and a few are engaged in the massive task of restructuring their relevant bodies of knowledge. It seems obvious that the complexity of the task of curriculum reform increases at least geometrically as more variables are added.

THE IACP STRUCTURE FOR THE BODY OF KNOWLEDGE IN INDUSTRIAL TECHNOLOGY

While organized religion, government, and the economic system each have their dominant function to fulfill, they interrelate with each other and with other societal institutions. Contemporary governmental activities in the economic sphere, and the family's role in religion are well recognized examples of such interrelationships. For analytical purposes, however, it may be desirable to focus on the primary or dominant role of a societal institution, not forgetting, of course, that these roles are intricately interlaced to form the total cultural fabric.

The Industrial Arts Curriculum Project adopted this analytical approach to its study of industrial technology. Industry's primary role is that of organizing resources and of substantially changing their form so that they yield the industrial material goods required to satisfy man's wants. A recognition of this dominant function does not necessarily overlook or minimize industry's tangential influence on and commitment to other major societal purposes.

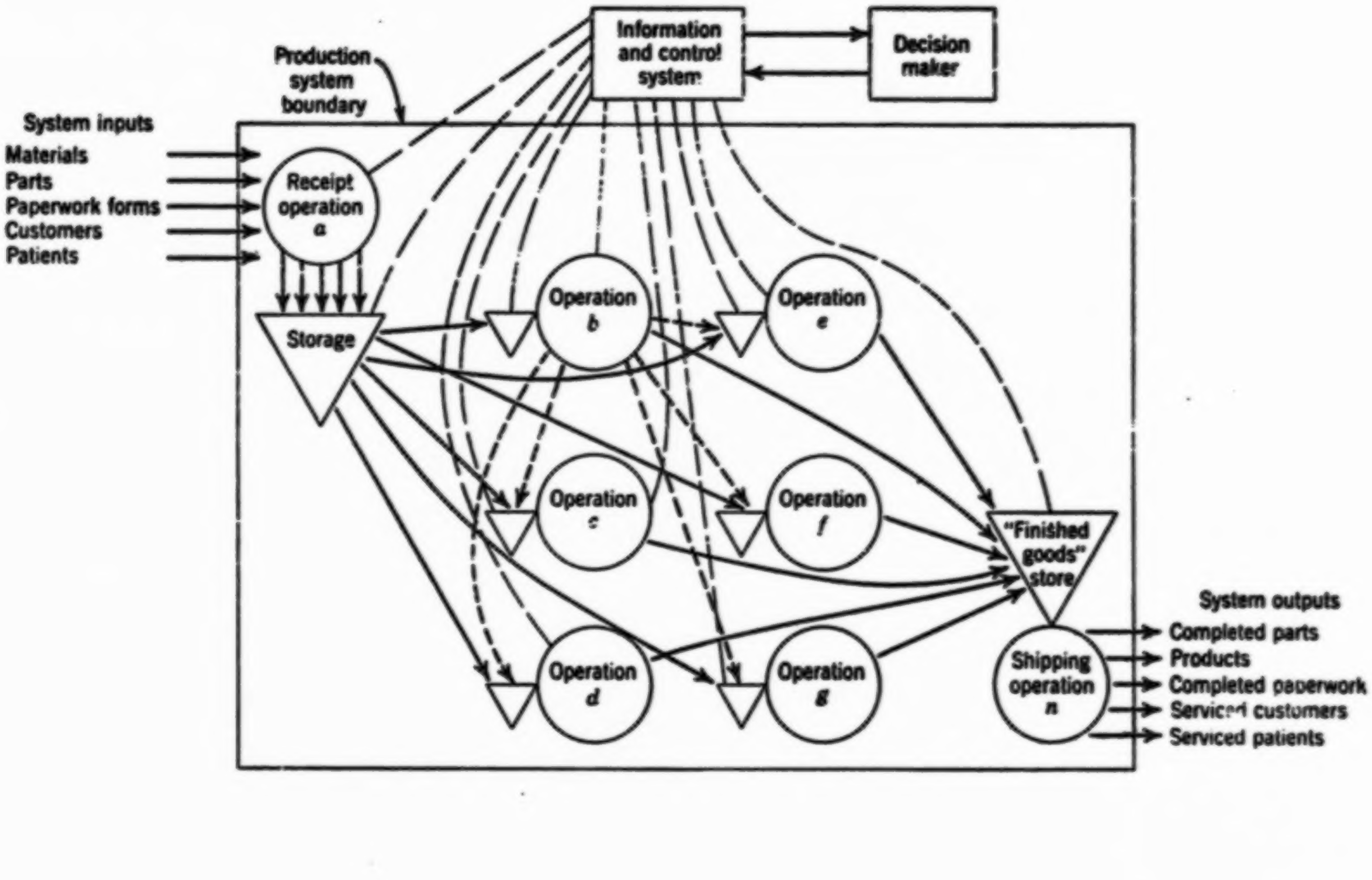
The IACP analysis begins with the identification of industry as a sub-element of the economic institution. A primary question, therefore, refers to the nature of the economic institution.

Buffa presents a generalized model of what may be called the economic institution, though he describes it as a model of production as it relates to the factory, the office, the supermarket, the hospital, etc. The model, shown in Figure XXII, has inputs (material, parts, paperwork

Figure XXII

Diagram of a Generalized Production System

Inputs may be processed in any specified sequence of operations and are transported between operations. The number of operations may vary from one to any finite number. Storage occurs between all operations, and the time in storage may vary from essentially zero to any finite amount. Note: There are interconnections between all combinations of operations b through f although only those originating at b are shown. The information system interconnects all activities and provides the basis for management decision (Buffa, 1965, p. 33).


Information and control system
Decision maker
Production system boundary
System inputs
Materials
Parts
Paperwork forms
Customers
Patients
Receipt operation a
Storage
Operation b
Operation e
Operation c
Operation f
"Finished goods" store
Operation d
Operation g
Shipping operation n
System outputs
Completed parts
Products
Completed paperwork
Serviced customers
Serviced patients

forms, and customers or patients), operations (mechanical, chemical, assembly, inspection and control, dispatching to the next operation, receiving, shipping, personal contact, such as an interview, and paperwork operations), and outputs (completed products, chemicals, service to customers or patients, completed paperwork, etc.). The model also includes an information system and a decision maker. The former is essentially the feedback system to provide the basis for management decisions (Buffa, 1965, pp. 31-34).

What Buffa defines as the "production system boundary" excludes the "information and control system" and the "decision maker" as well as "inputs" and "outputs." It does not present management practices as being within the production system. Also, it does not indicate that "operations" are of two principal types, those which primarily affect things, and those which primarily affect people.

Figure XXIII presents a paradigm which is generally applicable to all sub-elements of the economic institution and which includes the complete sequence. The cycle commences with an act of initiation in which a human want or need is identified or anticipated. Resources--consisting of energy, natural, human, finance, capital (tools and facilities), and knowledge--are selected as inputs to the productive system. These resources are processed in accordance with practices appropriate to the particular field of economic activity. The outputs of this productive system are the distributed economic goods, containing added form, place, possession, and/or time utility. To complete the economic continuum, these

Figure XXIII

A PARADIGM OF THE ECONOMIC INSTITUTION

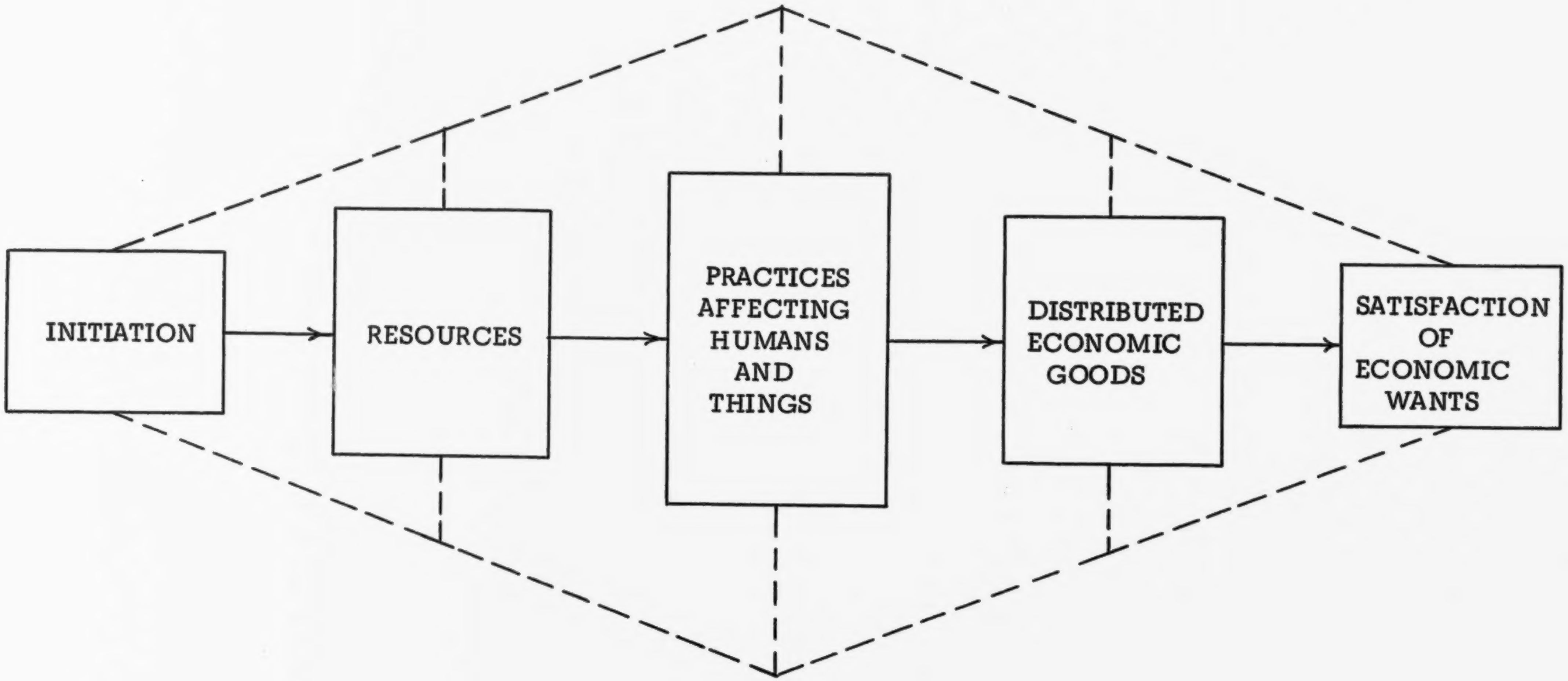
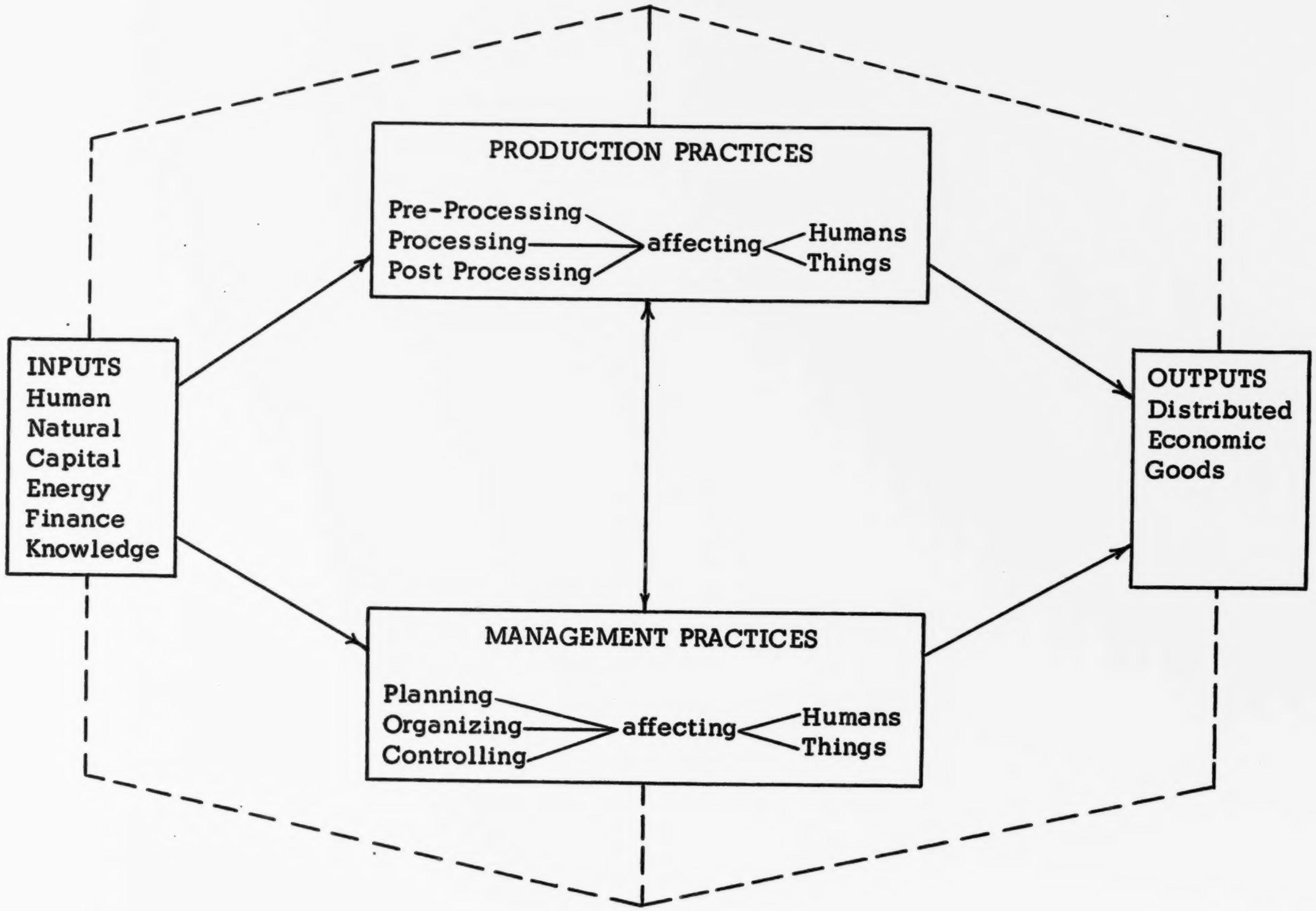

INITIATION
RESOURCES
PRACTICES AFFECTING HUMANS AND THINGS
DISTRIBUTED ECONOMIC GOODS
SATISFACTION OF ECONOMIC WANTS

Figure XXIV

MAJOR GROUPS OF PRACTICES IN THE ECONOMIC INSTITUTION


PRODUCTION PRACTICES
Pre-Processing
Processing
Post Processing
affecting
Humans
Things
INPUTS
Human
Natural
Capital
Energy
Finance
Knowledge
OUTPUTS
Distributed
Economic
Goods
MANAGEMENT PRACTICES
Planning
Organizing
Controlling
affecting
Humans
Things

distributed goods are the means by which human wants are satisfied. While the orientation of this total process is linear--from initiation to the satisfaction of wants--extensive recirculation or feedback is represented in the diagram by broken lines connecting all of the major stages.

Since this paradigm applies generally to the economic institution of society, it is possible to trace the activities of any specific economic establishment, or any group of establishments, through the sequence. A particular retail establishment such as a furniture store, the entire banking business, or the manufacturing industries group, may be analyzed in terms of this model.

An expansion of the "practices" aspect of this economic paradigm is depicted in Figure XXIV. All economic activity includes Production Practices and Management Practices which are brought to bear on the Resources that are put into the system. As indicated, these resources become the direct objects of both production and management practices. These practices exist only to affect either humans or things.

Economic value is added as resources are processed through efficient management and production practices. Production consists of Pre-Processing, Processing, and Post-Processing practices. Storage and transfer practices may be involved within and between these sub-elements. Management practices include Planning, Organizing, and Controlling. All sub-elements are intimately interrelated, either linearly through a central sequence or peripherally through a feedback process. In the former sense, Planning, Organizing, and Controlling are in the main linear, while Production practices provide a valuable feedback function to aid subsequent Planning.

The knowledge of efficient economic practices may be called economic technology. A way of visualizing the interrelationships within economic technology is by means of a three-dimensional matrix.

Figures XXV and XXVI, respectively, represent the first order and the second order matrices of the technology of the economic institution. In the former, the most general (yet complete) economic equation is: management technology combined with production technology yields economic goods. The second order matrix (Figure XXVI) depicts the sub-elements along each of the axes. Economic technology contains bodies of knowledge of various sizes and orientations. For example, one might study Planning as it relates to all Production Technology resulting in all Economic Goods, e.g., the body of knowledge between a b c d and e f g h. More specifically, Planning may be considered as it relates to Production Technology involved in yielding Material Goods, that is, the body of knowledge between a i j d, and e k l h. It should be pointed out that the foregoing analysis is not intended as a mathematical model of the economic institution. Its usefulness is primarily as a conceptual model from which a structure for the body of knowledge in industrial technology may be developed.

While it is felt that this paradigm is conceptually sound, its broad applicability to the total economic institution, as well as to specific enterprises, diffuses its analytic power. The substantive sub-elements within

Figure XXV

A FIRST ORDER MATRIX
OF THE TECHNOLOGY OF THE ECONOMIC INSTITUTION

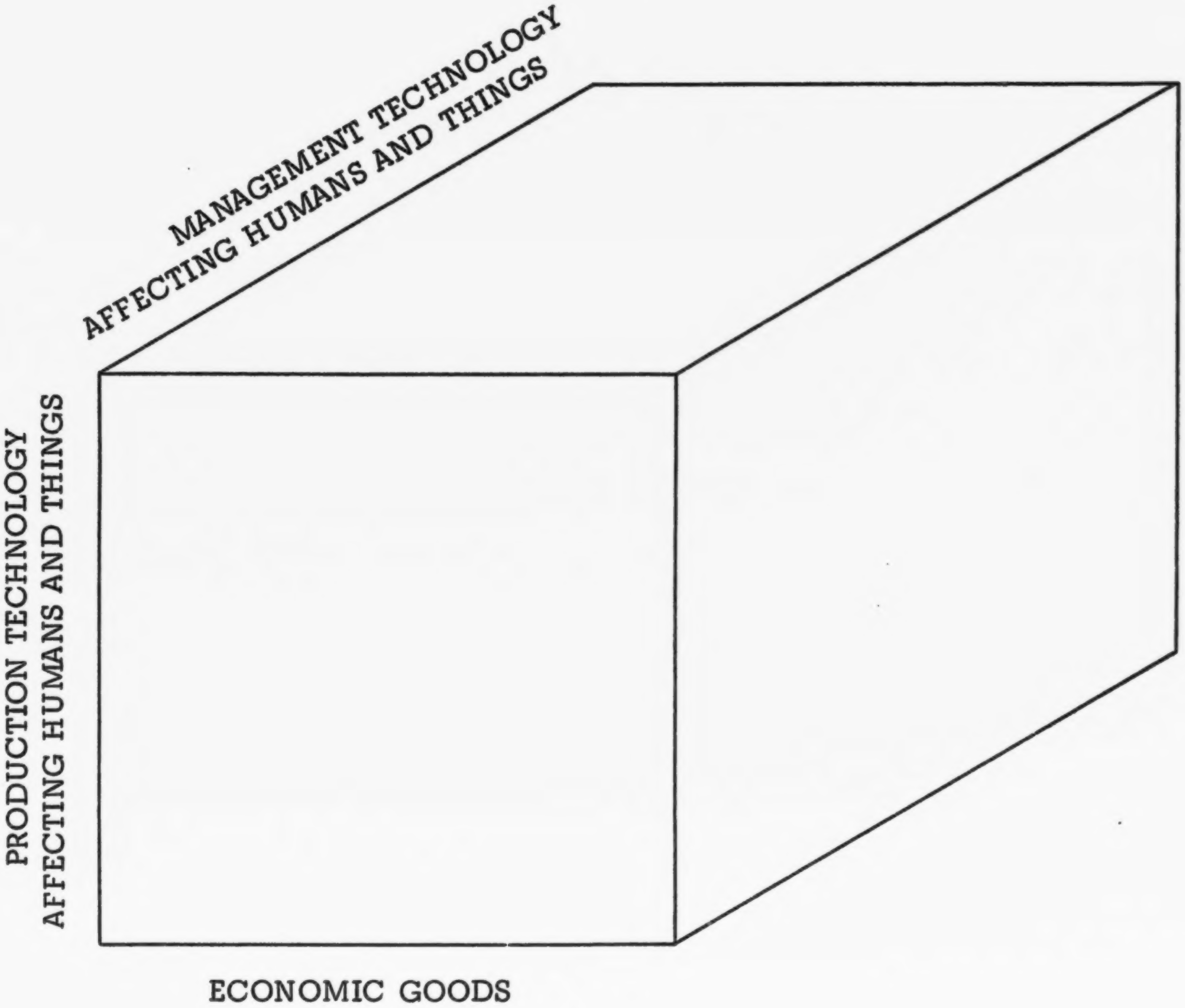
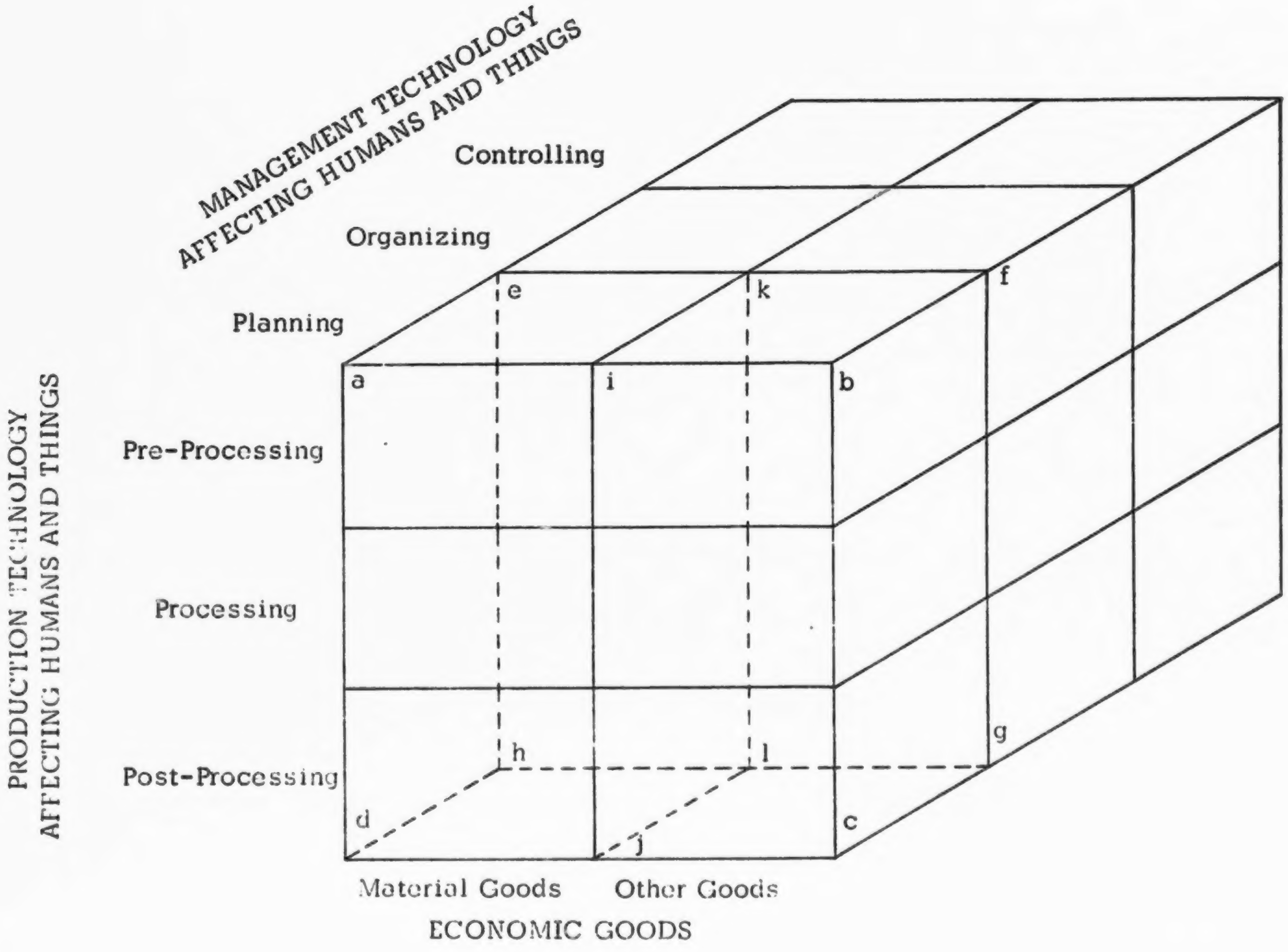

MANAGEMENT TECHNOLOGY
AFFECTING HUMANS AND THINGS
PRODUCTION TECHNOLOGY
AFFECTING HUMANS AND THINGS
ECONOMIC GOODS

Figure XXVI

A SECOND ORDER MATRIX
OF THE TECHNOLOGY OF THE ECONOMIC INSTITUTION


MANAGEMENT TECHNOLOGY
AFFECTING HUMANS AND THINGS
Controlling
Organizing
Planning
PRODUCTION TECHNOLOGY
AFFECTING HUMANS AND THINGS
Pre-Processing
Processing
Post-Processing
a
i
b
e
k
f
h
l
g
d
j
c
Material Goods
Other Goods
ECONOMIC GOODS

each of the major groups of practices cover the broadest possible spectrum of generically related activities. Thus, while the preprocessing involved in the operation of a hospital and an automobile factory are contained within the same sub-element (preprocessing), their substantive idiosyncrasies are so pronounced that the paradigm must be judged superficial. It is, therefore, necessary to reduce the applicability range of the model to increase its substantive precision.

One way to delimit the generality of the model, is to select only a part of the economic institution. Industry is defined as that sub-element of the economic institution responsible for substantially changing the form of the materials required to satisfy man's wants and is the appropriate domain for further conceptual development for industrial arts. That this delimitation restricts the scope of the structure is readily acknowledged. Banking, distribution, and transportation services are examples of economic activities that are excluded at this point. This is not to say that structures for the bodies of knowledge in these fields cannot or ought not to be developed. On the contrary, while such developmental work is essential, it lies outside the immediate scope of the present investigation.

Further analysis along these lines led to the development of matrices detailing the structure of industrial technology. Figure XXVII, the first order matrix of industrial technology, indicates that industrial management technology combined with industrial production technology yield industrial material goods and affect humans and things.

Figure XXVII

FIRST ORDER MATRIX OF INDUSTRIAL TECHNOLOGY

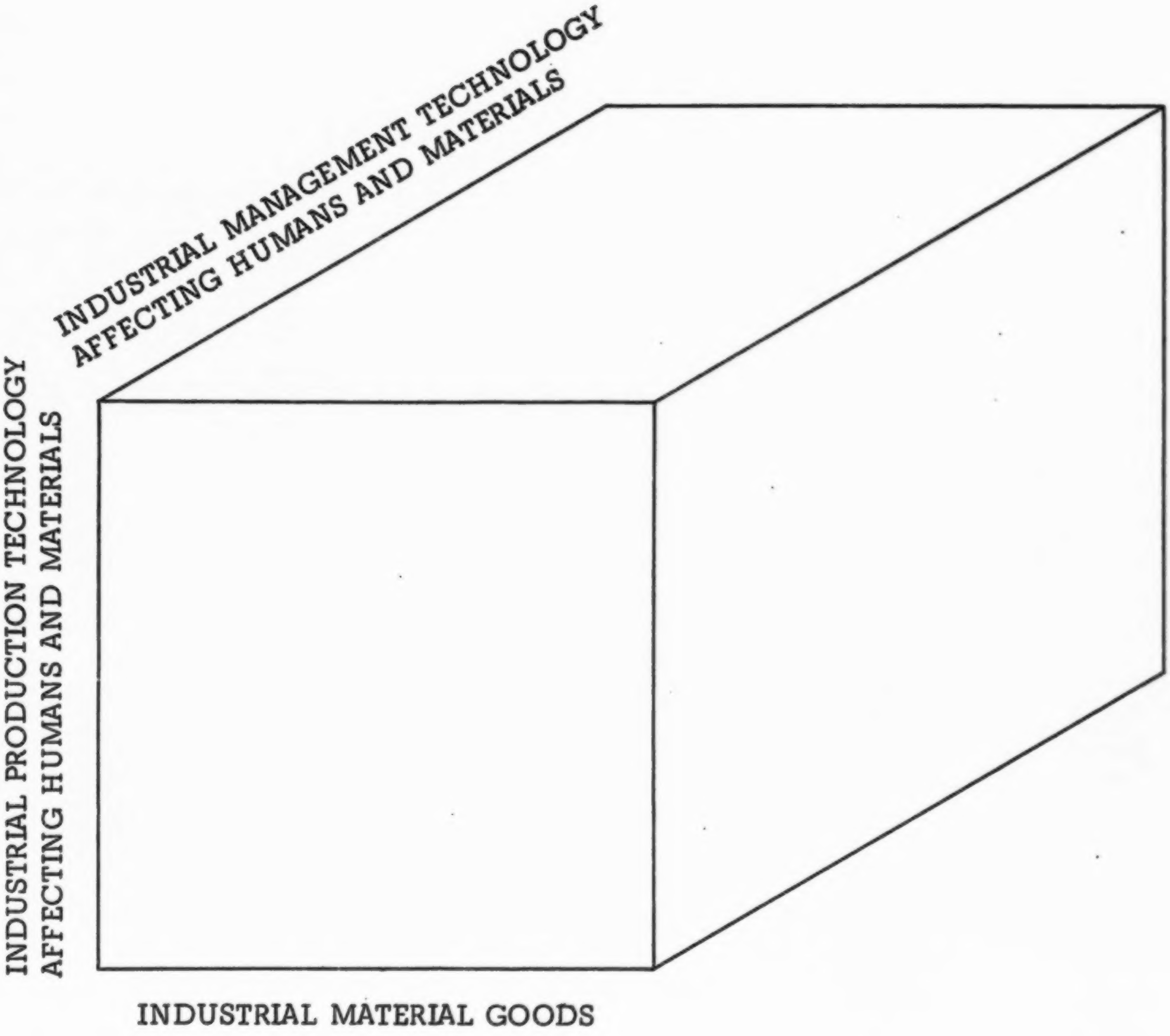
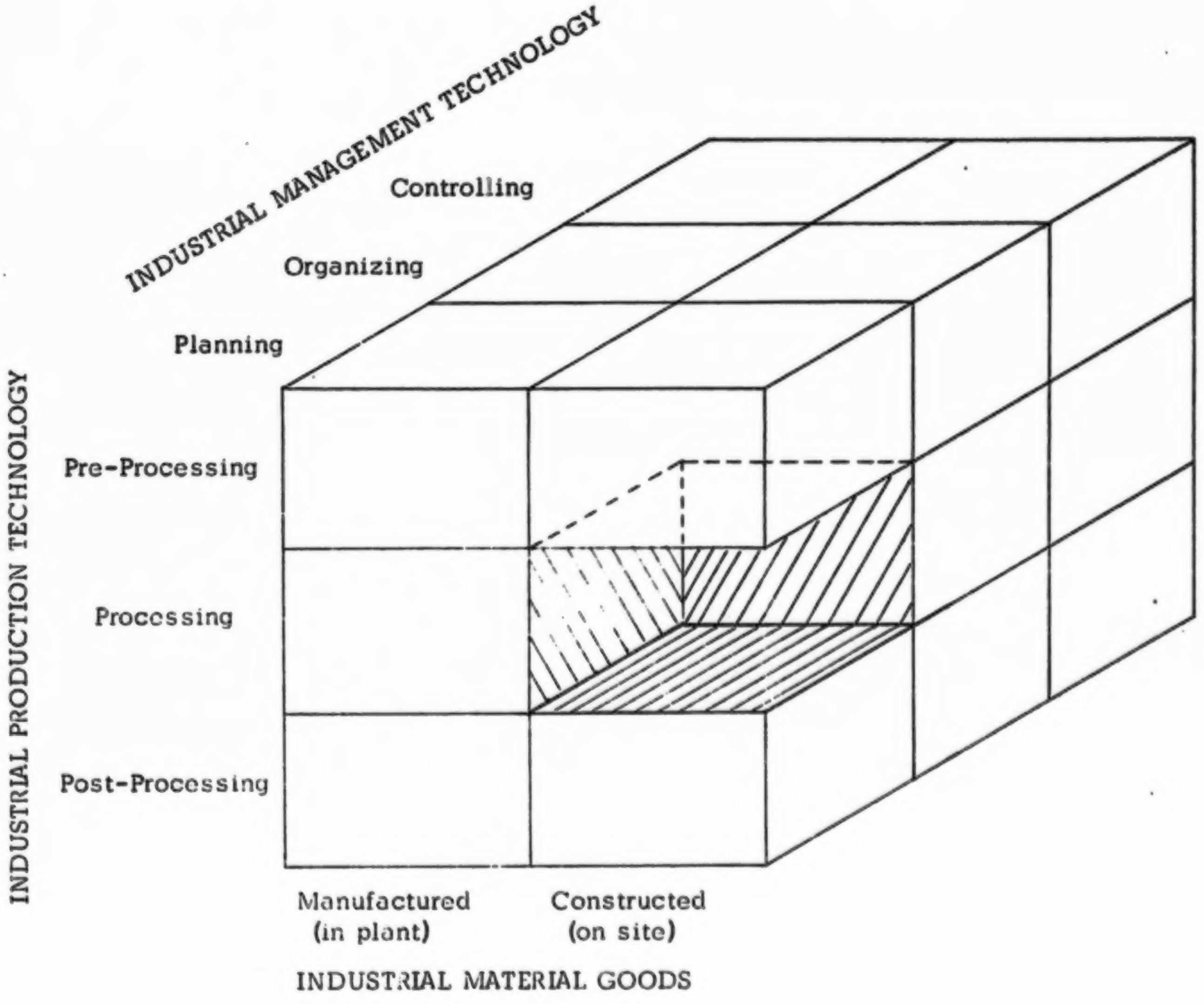

INDUSTRIAL MANAGEMENT TECHNOLOGY
AFFECTING HUMANS AND MATERIALS
INDUSTRIAL PRODUCTION TECHNOLOGY
AFFECTING HUMANS AND MATERIALS
INDUSTRIAL MATERIAL GOODS

Figure XXVIII

SECOND ORDER MATRIX
OF INDUSTRIAL TECHNOLOGY AFFECTING MATERIALS


INDUSTRIAL MANAGEMENT TECHNOLOGY
Controlling
Organizing
Planning
INDUSTRIAL PRODUCTION TECHNOLOGY
Pre-Processing
Processing
Post-Processing
Manufactured
(in plant)
Constructed
(on site)
INDUSTRIAL MATERIAL GOODS

Subsequent figures separately categorize those practices which primarily affect humans and those which primarily affect materials.

For analytical purposes, the practices which affect human behavior must be separated from the production setting, although it is clear that the electroplating process, for example, cannot be separated from concerns for exhausting noxious fumes properly, and for providing proper protective shielding for workers. However, industrial health is a universal concern throughout the establishment, and this fact is evident only when its many related practices are placed within some meaningful, all-encompassing construct. Thus, the broadest generalizations about industrial technology to affect worker safety may be identified independently of their specific applications throughout the production environment.

Figure XXVIII depicts the second order matrix only of that portion of industrial technology which primarily affects materials. This follows the pattern introduced in Figure XXVII, except that Industrial Material Goods have been separated into Manufactured and Constructed Industrial Material Goods. A sample third order matrix is shown in Figure XXIX. The shaded area from Figure XXVIII has been expanded in this figure to show that formulating, researching, designing, and engineering are sub-elements under Planning; while preparing the site, building the structure, and completing the site are sub-elements under Processing. At this level, Constructed Industrial Material Goods are divided into buildings and non-buildings.

A separate but parallel structure of industrial technology which affects human behavior in industry is shown in Figure XXX. This technology

Figure XXIX

SAMPLE THIRD ORDER MATRIX
OF INDUSTRIAL TECHNOLOGY AFFECTING MATERIAL

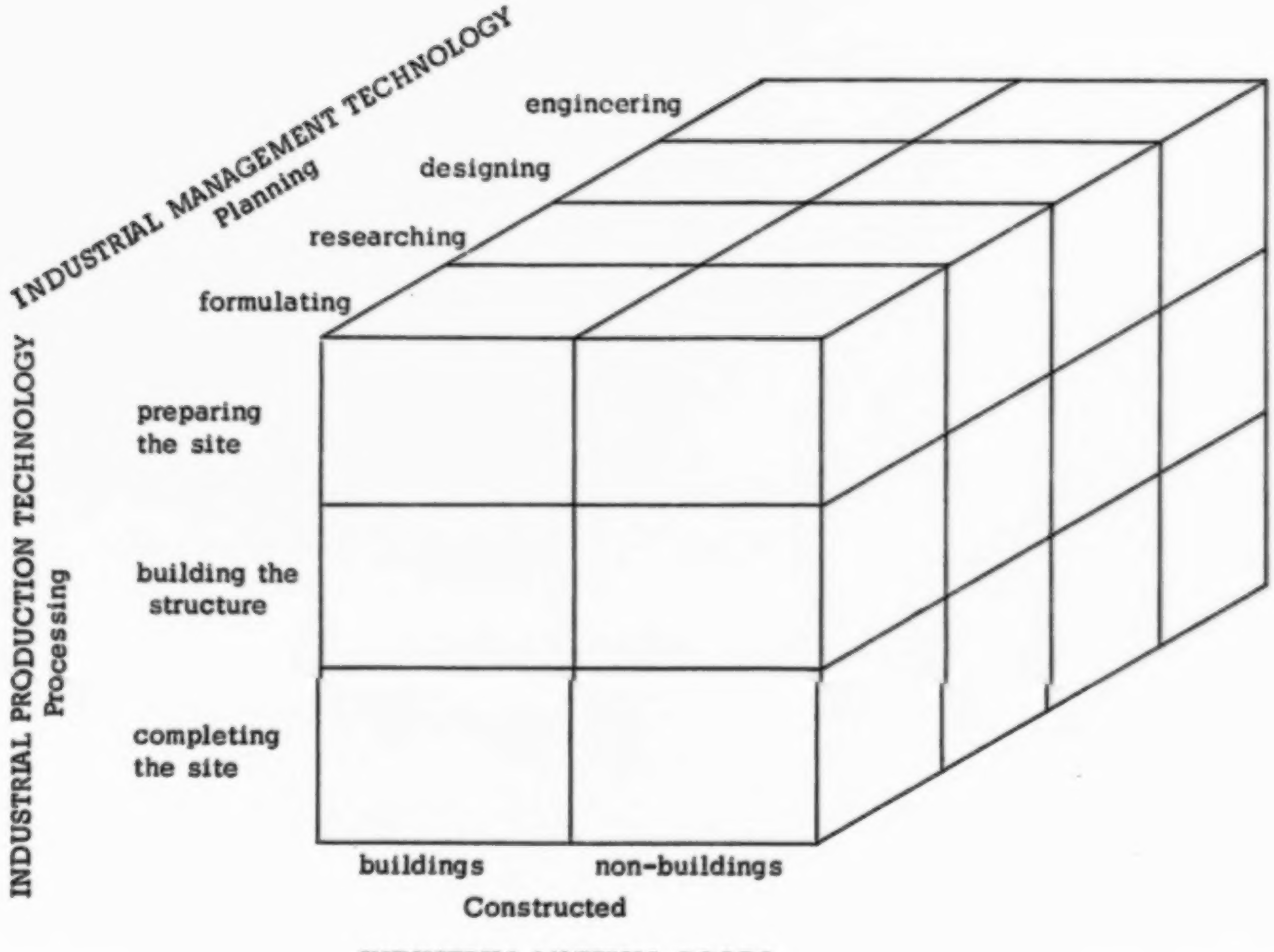
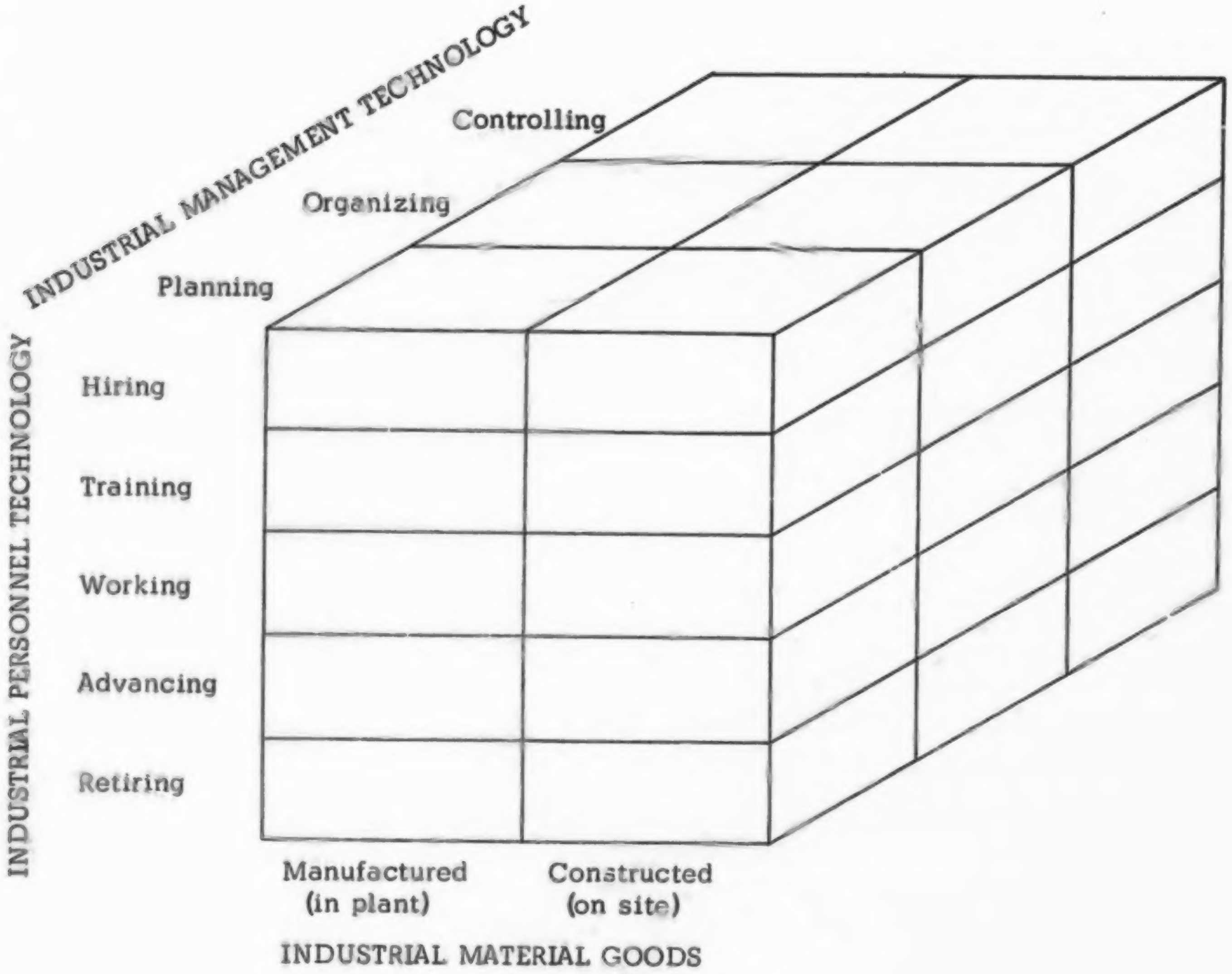

INDUSTRIAL MANAGEMENT TECHNOLOGY
Planning
engineering
designing
researching
formulating
INDUSTRIAL PRODUCTION TECHNOLOGY
Processing
preparing the site
building the structure
completing the site
buildings
non-buildings
Constructed
INDUSTRIAL MATERIAL GOODS

Figure XXX

SECOND ORDER MATRIX
OF INDUSTRIAL TECHNOLOGY AFFECTING HUMANS


INDUSTRIAL MANAGEMENT TECHNOLOGY
Controlling
Organizing
Planning
INDUSTRIAL PERSONNEL TECHNOLOGY
Hiring
Training
Working
Advancing
Retiring
Manufactured
(in plant)
Constructed
(on site)
INDUSTRIAL MATERIAL GOODS

is Planned, Organized, and Controlled by management as it affects humans through: Hiring, Training, Working, Advancing (up, down, or out), and Retiring the humans in the system. This technology often is different in manufacturing and in construction. The similarities and differences provide further insight into its nature.

It should be repeated that while one can look separately at industrial technology which primarily affects materials and that which primarily affects humans, their interrelationships in the production setting are at least as important as their separate entities. It is this latter fact which often is ignored when either type of technology is studied with disregard for the other, something the adequate industrial arts program should not do.

The matrix approach being used in this analysis provides a unique way of looking at the multiple dimensions of this body of knowledge.

Levels of specificity may be added to the model on all or on selected dimensions. It is possible, for example, to expand the "industrial production" axis to a high level of refinement, while retaining the generality of the "industrial goods" and the "industrial management" dimensions. If all three dimensions were extensively developed, it would be theoretically possible to select an infinite number of "tailor-made" combinations of subject matter from the matrix. Thus, while the primary responsibility of the Industrial Arts Curriculum Project is directed toward industrial arts at the junior high school level, the principal analytical device (the matrix of industrial technology) has potential applicability at all grade and sophistication levels.

The possibilities for further development of the IACP Matrix along systematic and analytically defensible lines seem bright. The conceptual research must be continued in a disciplined, vigorous manner until the structure has been sufficiently developed to permit the content selection process to commence.

CONCLUDING STATEMENT

The Generalized Model of Industrial Technology presented must not be construed as the ultimate or definitive structure for the body of knowledge from which industrial arts subject matter is to be selected. It represents the most advanced and most promising conceptual construct that the Project staff has been able to conceive. Its tentative quality is openly admitted, as all conceptual schemes are subject to review, refinement, and modification. Additional investigations, experimentation, and eventual widespread implementation will assist in evolving this structure. The reliability and validity of the generalized model will be enhanced to the extent that curriculum workers can be mobilized for its development.

Chapter IV

Details of the Structure

The rationale and a gross structure for industrial technology have been posited in the first three chapters. This Chapter presents additional details of that gross structure.

Consultants from the several substantive fields related to industry have assisted in the identification and ordering of these details. However, this process will continue and a refinement of these details will result.

CHARACTERISTICS AND RELATIONSHIPS

The gross structure of industrial technology presented in Chapter III was communicated by the use of three-dimensional matrices or arrays. As the analysis of the structure progressed and more detail (higher order of specificity) was identified, it became obvious that space would not permit graphic three-dimensional presentation. Therefore, an outline form is used in this Chapter to present successive orders of specificity.

The reader will recall the three major axes of the first order matrix of industrial technology from Figure XXVII, page 158. These axes were:

Industrial Management Technology Affecting Humans
    and Materials
Industrial Production Technology Affecting Humans
    and Materials
Industrial Material Goods

That figure portrayed the interrelationships between practices with humans and materials. However, as was pointed out in the discussion on page 160, industrial technology which primarily affects human behavior may be artificially extracted from the whole for purposes of analysis and explication, Figure XXX, page 162. Therefore, the following outline is used in this chapter:

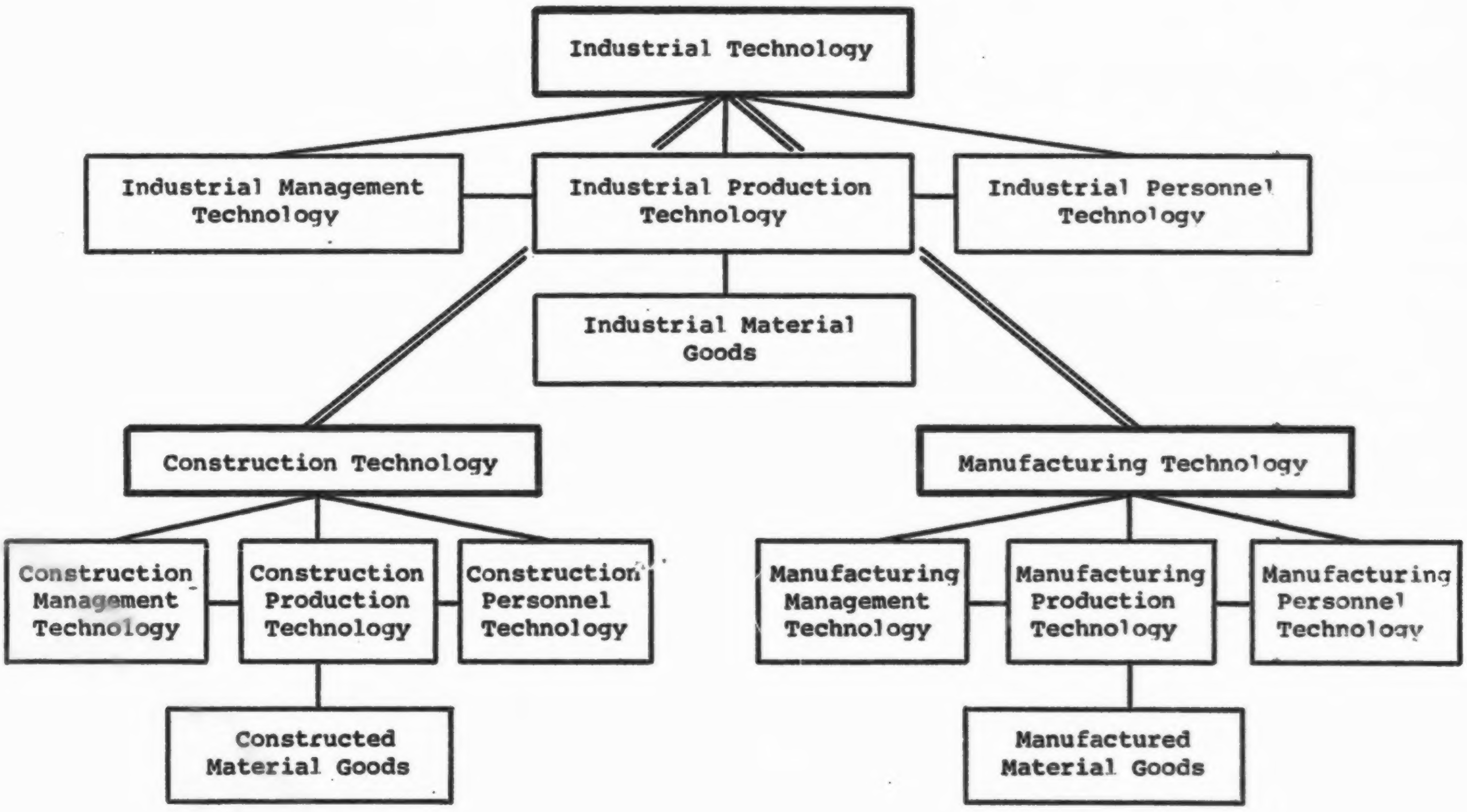
I. INDUSTRIAL MANAGEMENT TECHNOLOGY
II. INDUSTRIAL PRODUCTION TECHNOLOGY
III. INDUSTRIAL PERSONNEL TECHNOLOGY
IV. INDUSTRIAL MATERIAL GOODS
V. CONSTRUCTION TECHNOLOGY
VI. MANUFACTURING TECHNOLOGY

Figure XXXI graphically portrays the interrelationships between the elements of this Chapter. It should be noted that there is a generalized structure of industrial technology and, at a more specialized level, there are substructures of construction technology and of manufacturing technology.

An instructional program could focus on any one or any combination of these three structures or their subelements. For example, one could study the generalized structure of industrial technology and not the more specialized substructures. Also, given another purpose, one could study only construction technology or some subelement of it. At a more specific level, one could organize the knowledge of general industrial drafting, or one could organize the knowledge of construction drafting or the knowledge of drafting in manufacturing. The more generalized knowledge would in some ways be applicable to both types of more specialized

Figure XXXI

MAJOR STRUCTURAL ELEMENTS
IN INDUSTRIAL TECHNOLOGY


Industrial Technology
Industrial Management Technology
Industrial Production Technology
Industrial Personnel Technology
Industrial Material Goods
Construction Technology
Manufacturing Technology
Construction Management Technology
Construction Production Technology
Construction Personnel Technology
Constructed Material Goods
Manufacturing Management Technology
Manufacturing Production Technology
Manufacturing Personnel Technology
Manufactured Material Goods

drafting, but would not enable a draftsman to take a surveyor's notebook and make a topographical map. Similarly, the knowledge of how to make the topographical map would be inadequate to enable one to make an assembly drawing of a manufactured product.

In further explanation of the interrelationships between elements, industrial management technology may be examined as a more detailed example of the workings of the structure. Industrial management may be structured as a discrete set of bits of knowledge which are generally applicable across both construction and manufacture. Planning, as generalized efficient actions in industry, can be analyzed and codified. This knowledge will stop short of the distinctions between the industrial (manufacturing) designer and the architectural (construction) designer. To pursue the structuring of the more specialized knowledge of the efficient actions of the specialists in construction and in manufacturing, it is efficient to go to substructures which separately classify these more detailed elements.

Before proceeding with a detailing of the structure of the body of knowledge which has been identified as industrial technology, it should be noted once again that this is a single body of knowledge of how to efficiently produce industrial material goods. However, for purposes of simplification and suitability as a basis for instruction the single body of knowledge is separated into the parts indicated by the major sections of this Chapter.

Stated differently, industrial management technology which affects humans and materials when combined with industrial production technology which affects humans and materials yields industrial material goods. This technology is the body of knowledge of how to efficiently produce industrial goods and it may be studied as a single, integrated body of knowledge. However, by providing the major themes of management, production and personnel technology the gross structure is simplified by reduction into several major elements. In addition, the more specialized substructures of construction and manufacturing technology subdivide the more specialized elements. Presumably, this provides more ready access for a learner who would be discouraged when confronted with a single, more complex structure.

General Character of Structure. It will be noted that the entries in the outline are verbal nouns, or gerunds, which connote "action" or "doing." Some entries are single terms while others are phrases introduced by gerunds. These statements appear as major classes as well as subclasses.

Structure implies the ordering of bits and pieces into meaningful wholes. Structure suggests ordering of specifics and relating them to generalizations. This ordering of "particulars" and "classes" provides transfer of learning potential. By carefully delineating the "elements" within the "context," and by conceptualizing themes that organize and unify, curriculum workers will more adequately structure knowledge, design curricula, and prepare teaching-learning materials which provide pupils with greater knowledge and skills.

Although the listing appears to progress in a linear fashion, many cycles or loops are common in actual practice. For example, "planning" appears first in the listing of industrial management technology. However, it is common to have the planning function continue throughout production, or to have feedback from "controlling" indicate that replanning is necessary to correct an original planning inadequacy. This same situation obtains at other levels of specificity also. Therefore, although the structural elements are listed in linear form, there are many occasions for cyclical or feedback action.

Attention should be called again to the proposition that the body of knowledge delineated in this chapter (industrial technology) serves many educational purposes at all levels of the educational ladder. The curriculum planner could extract a syllabus for collegiate course work in production management. In a like manner, materials could be developed for doctoral level investigation in industrial psychology. To this list could be added programs for the elementary school (broad understanding of major categories), specialized courses in welding, and activities and studies for the civil or the industrial engineer.

The structure provides the industrial arts curriculum planner with a classification system that should assist in selecting or sampling industrial practices at comparable levels of generality or specificity. Such a selection would preclude an undue emphasis upon one or more topics to the exclusion of other important ones. The structure provides for the study of an integrated industrial system, with special attention given to the elements within the production boundary, and with general attention given to the inputs and outputs of that system.

One last general characteristic of the structure should be pointed out because of its implication for curriculum development. A major problem of contemporary industry is obsolescence of industrial knowledge. The advantage of this system of classification, in this regard, is seen in the generality of the major classes. The more general classes remain relatively stable, but change is ever more rapid with increasing specificity. Therefore, the higher levels of generalization are more durable and of greatest long-term value to the learner. This is not to say that the details are insignificant to the formulation of the generalizations, but the higher levels of generalization are more stable.

Relationship of Technology to Products. The taxonomy of industrial technology has been developed with little or no regard to a resulting product. However, the operational significance of the system is exhibited when a specific product is traced through it. Once the goal is established to manufacture a toothbrush or to construct a driveway, for example, the appropriate management, production and personnel practices may be identified and studied as they relate to the particular product. The largely custom nature of constructed products makes construction technology more related to product than is manufacturing technology. Therefore, the system takes on even greater meaning when both constructed and manufactured products are selected purposefully to explicate the various dimensions of the structure.

Relationship of Management, Production, and Personnel. It is difficult to draw a sharp line between management, production and personnel. These major categories of the structure interrelate at many points. Most production workers are managers to some extent and *vice versa*. The carpenter on a construction job measures and checks his work against the plan and thereby is performing a control function listed under management. On the other hand, the product designer produces form utility as he develops the prototype of a new product. In the last analysis, the distinction between production workers and managers is based upon the proportion of the time each performs a particular function, and both are affected by personnel practices which effect the economic, physical, and social conditions related to their work environments.

It can be demonstrated that industrial management technology does affect both materials (production) and humans (personnel). It can be seen that the manager who formulates production goals by deciding on what material products to produce simultaneously determines, in at least a general way, what kinds of work the humans in the system will be doing. The opposite also may be true. Management may survey its manpower situation and then formulate material production goals. Therefore, industrial management technology may be viewed as a body of knowledge which plans, organizes, and controls humans in a material production system. One can focus on affecting human behavior or on affecting materials, but an integrated view forms the basis for industrial management technology as it is detailed in the first section of this Chapter.

Management plans, organizes the inputs to the system (to implement the plan), and controls the plan and organization to produce products. Production actually produces the product while assuming selected minor management responsibilities. And throughout the system the human and how to affect his behavior remains the most critical element.

The detailed structure of management technology presented in the next section is equally applicable to manufacturing and construction. At higher orders of specificity, it is anticipated that unique management practices will be identified which relate specifically to either construction or manufacturing. At that level, however, by definition, these practices lose their general applicability.

I. INDUSTRIAL MANAGEMENT TECHNOLOGY

1. Planning

- 1.1 Formulating
  - 1.1.1 Determining Goals
  - 1.1.2 Establishing Specific Objectives
  - 1.1.3 Setting Policies
  - 1.1.4 Forecasting
  - 1.1.5 Programming

- 1.2 Researching
  - 1.2.1 Retrieving
  - 1.2.2 Describing
  - 1.2.3 Experimenting

- 1.3 Designing
  - 1.3.1 Determining Function
  - 1.3.2 Preparing Performance Specification
  - 1.3.3 Postulating a Solution-in-Principle
  - 1.3.4 Making Simple Models
  - 1.3.5 Postulating Alternate Solutions
  - 1.3.6 Making Working or Scale Models
  - 1.3.7 Selecting Solution
  - 1.3.8 Communicating Design Solution
  - 1.3.9 Making Prototype

- 1.4 Engineering
  - 1.4.1 Detailing Design Communication
  - 1.4.2 Detailing Specifications and Standards
  - 1.4.3 Work Design (methods, standards, processes)
  - 1.4.4 Estimating
  - 1.4.5 Scheduling

2. Organizing

- 2.1 Structuring
  - 2.1.1 Analyzing Work Tasks
  - 2.1.2 Determining Worker Functions
  - 2.1.3 Establishing Roles
  - 2.1.4 Setting Work Conditions

- 2.2 Supplying
  - 2.2.1 Requisitioning
  - 2.2.2 Procuring and Subcontracting
  - 2.2.3 Routing
  - 2.2.4 Storing

3. Controlling

- 3.1 Directing
  - 3.1.1 Supervising
  - 3.1.2 Coordinating

- 3.2 Monitoring
  - 3.2.1 Inspecting
  - 3.2.2 Inventorying
  - 3.2.3 Timekeeping

- 3.3 Reporting
  - 3.3.1 Compiling
  - 3.3.2 Appraising
  - 3.3.3 Notifying

- 3.4 Correcting
  - 3.4.1 Adjusting
  - 3.4.2 Expediting
  - 3.4.3 Restraining
  - 3.4.4 Replanning
  - 3.4.5 Redirecting
  - 3.4.6 Retraining

II. INDUSTRIAL PRODUCTION TECHNOLOGY

1. Pre-processing

  1.1 Receiving

  1.2 Unpackaging

  1.3 Handling*
    1.3.1 Pumping and Compressing
    1.3.2 Elevating
    1.3.3 Carrying
    1.3.4 Filling
    1.3.5 Evacuating
    1.3.6 Attaching
    1.3.7 Operating
    1.3.8 Skidding

  1.4 Storing*

  1.5 Protecting

2. Processing

  2.1 Separating
    2.1.1 Classifying
      2.1.1.1 Screening
        2.1.1.1.1 Grizzly Screening
        2.1.1.1.2 Rotary Screening
        2.1.1.1.3 Shaking Screening
        2.1.1.1.4 Vibrating Screening
        2.1.1.1.5 Oscillating Screening
      2.1.1.2 Floating
        2.1.1.2.1 Subaerating Floating
        2.1.1.2.2 Pneumatic Floating
        2.1.1.2.3 Vacuum Floating
        2.1.1.2.4 Pressure Floating
      2.1.1.3 Sedimenting
        2.1.1.3.1 Batch Thickening
        2.1.1.3.2 Continuous Thickening
        2.1.1.3.3 Single Compartment Thickening
        2.1.1.3.4 Tray Thickening

---

* Handling and Storing practices, while listed here under Pre-Processing, are utilized throughout the production cycle. Thus, Carrying, Filling, and Elevating for example, will also occur between and within operations in the Processing category.

- 2.1.1.4 Filtering - Clarifying
    - 2.1.1.4.1 Cake Filtering
        - 2.1.1.4.1.1. Hydrostatic Head Filtering
        - 2.1.1.4.1.2 Pressure Filtering
        - 2.1.1.4.1.3 Vacuum Filtering
    - 2.1.1.4.2 Clarifying
        - 2.1.1.4.2.1 Disk and Plate Press Filtering
        - 2.1.1.4.2.2 Pre-coat Pressure Filtering
        - 2.1.1.4.2.3 Cartridge Clarifying
- 2.1.1.5 Magnetizing
    - 2.1.1.5.1 Tramp-Iron Magnetic Separating
        - 2.1.1.5.1.1 Magnetic Head Pulleys
        - 2.1.1.5.1.2 Suspended Magnets
        - 2.1.1.5.1.3 Magnetic Drums
        - 2.1.1.5.1.4 Plate Magnets
        - 2.1.1.5.1.5 Grate Magnets
    - 2.1.1.5.2 Concentration and Purification
        - 2.1.1.5.2.1 Wet Magnetic Separating
        - 2.1.1.5.2.2 Dry Magnetic Separating
- 2.1.1.6 Distilling
    - 2.1.1.6.1 Destructive Distilling
    - 2.1.1.6.2 Batch Distilling
    - 2.1.1.6.3 Extractive Distilling
    - 2.1.1.6.4 Rectifying
    - 2.1.1.6.5 Dephlegmatizing
    - 2.1.1.6.6 Flash Distilling
    - 2.1.1.6.7 Simple Distilling
    - 2.1.1.6.8 Refluxing
    - 2.1.1.6.9 Fractional Distilling
    - 2.1.1.6.10 Azeotropic Distilling
    - 2.1.1.6.11 Vacuum Distilling
    - 2.1.1.6.12 Molecular Distilling
- 2.1.1.7 Evaporating
    - 2.1.1.7.1 Forced Circulation Evaporating
    - 2.1.1.7.2 Short-Tube Vertical Evaporating
    - 2.1.1.7.3 Long-Tube Vertical Evaporating
    - 2.1.1.7.4 Horizontal Tube Evaporating
    - 2.1.1.7.5 Agitated Film Evaporating
    - 2.1.1.7.6 Grainer Evaporating
    - 2.1.1.7.7 Submerged Combustion Evaporating
    - 2.1.1.7.8 Disk or Cascade Evaporating
    - 2.1.1.7.9 Flash Evaporating

- 2.1.1.8 Centrifuging
  - 2.1.1.8.1 Ultracentrifuge
  - 2.1.1.8.2 Tubular Bowl Centrifuge
  - 2.1.1.8.3 Hydrocyclone Centrifuge
- 2.1.1.9 Drying
  - 2.1.1.9.1 Direct Drying
    - 2.1.1.9.1.1 Direct Continuous Drying
    - 2.1.1.9.1.2 Direct Batch Drying
  - 2.1.1.9.2 Indirect Drying
    - 2.1.1.9.2.1 Indirect Continuous Drying
    - 2.1.1.9.2.2 Indirect Batch Drying
  - 2.1.1.9.3 Radiant Heat Drying
  - 2.1.1.9.4 Dielectric Heat Drying
- 2.1.1.10 Adsorbing
  - 2.1.1.10.1 Gas (or Vapor) on Solid Adsorption
  - 2.1.1.10.2 Gas (or Vapor) on Liquid Adsorption
  - 2.1.1.10.3 Liquid on Liquid Adsorption
  - 2.1.1.10.4 Solid on Solid Adsorption
- 2.1.1.11 Absorbing
  - 2.1.1.11. 1 Plate Tower Absorbing
  - 2.1.1.12.2 Sieve Tray Absorbing
  - 2.1.1.13.3 Spray Tower Absorbing
  - 2.1.1.14.4 Cyclone Scrubber Absorbing
  - 2.1.1.15.5 Wetted-wall Column Absorbing
- 2.1.1.12 Crushing
  - 2.1.1.12.1 Primary Crushing
    - 2.1.1.12.1.1 Jaw Type Crushing
    - 2.1.1.12.1.2 Gyratory Crushing
    - 2.1.1.12.1.3 Cone Crushing
  - 2.1.1.12.2 Secondary Crushing
    - 2.1.1.12.2.1 Hammer Crushing
    - 2.1.1.12.2.2 Roll Crushing
      - 2.1.1.12.2.2.1 Smooth Roll Crushing
      - 2.1.1.12.2.2.2 Corrugated or Toothed-Roll Crushing
- 2.1.1.13 Milling
  - 2.1.1.13.1 Tumbling Milling
    - 2.1.1.13.1.1 Ball Milling
    - 2.1.1.13.1.2 Pebble Milling
    - 2.1.1.13.1.3 Rod Milling
    - 2.1.1.13.1.4 Tube Milling

    - 2.1.1.13.2 Ring Roller Milling
      - 2.1.1.13.2.1 Bowl Milling
    - 2.1.1.13.3 Hammer Milling
      - 2.1.1.13.3.1 Disintegrated Hammer Milling
      - 2.1.1.13.3.2 Vertical Hammer Milling
      - 2.1.1.13.3.3 Impact Hammer Milling
    - 2.1.1.13.4 Disk Attrition Milling
    - 2.1.1.13.5 Pin-Type Milling
    - 2.1.1.13.6 Buhrstone Milling
    - 2.1.1.13.7 Dispersion & Colloid Milling
      - 2.1.1.13.7.1 Sand Milling
    - 2.1.1.13.8 Jet Milling
    - 2.1.1.13.9 Flash Pulverization
    - 2.1.1.13.10 Roller Milling (for paint grinding & flour milling)
  - 2.1.1.14 Leaching
    - 2.1.1.14.1 Percolation Leaching
      - 2.1.1.14.1.1 Open Tank or Vat Leaching
      - 2.1.1.14.1.2 Diffusion Battery Leaching
      - 2.1.1.14.1.3 Rake Classifying
      - 2.1.1.14.1.4 Bucket-Elevator Contactors
      - 2.1.1.14.1.5 Screw-Conveyor Contactors
      - 2.1.1.14.1.6 Horizontal Disk Contactors
    - 2.1.1.14.2 Dispersed-Solid Leaching
      - 2.1.1.14.2.1 Agitated Vessels
        - 2.1.1.14.2.1.1 Simple Agitators
        - 2.1.1.14.2.1.2 Pachuca Tanks
      - 2.1.1.14.2.2 Gravity Thickeners
      - 2.1.1.14.2.3 Continuous Centrifuges
  - 2.1.1.15 Stripping
    - 2.1.1.15.1 Pressure Reduction Stripping
    - 2.1.1.15.2 Heat Stripping
    - 2.1.1.15.3 Inert Gas Stripping
  - 2.1.1.16 Electrostatic Separating
    - 2.1.1.16.1 Contact Electrification
    - 2.1.1.16.2 Conductive Induction
    - 2.1.1.16.3 Ion Bombardment

- 2.1.2 Material Removing
  - 2.1.2.1 Turning

- 2.1.2.1.1 Lathe Turning
  - 2.1.2.1.1.1 Engine Lathe Turning
  - 2.1.2.1.1.2 Bench Lathe Turning
  - 2.1.2.1.1.3 Toolroom Lathe Turning
  - 2.1.2.1.1.4 Speed Lathe Turning
  - 2.1.2.1.1.5 Duplicating Lathe Turning
  - 2.1.2.1.1.6 Gap Bed Lathe Turning
  - 2.1.2.1.1.7 Turret Lathe Turning
    - 2.1.2.1.1.7.1 Vertical Turret Lathe
    - 2.1.2.1.1.7.2 Horizontal Turret Lathe
- 2.1.2.1.2 Screw Machine Turning
  - 2.1.2.1.2.1 Single Spindle Screw Machine
  - 2.1.2.1.2.2 Multiple Spindle Screw Machine
- 2.1.2.1.3 Chucking Machine Turning
  - 2.1.2.1.3.1 Horizontal Chucking Machine
    - 2.1.2.1.3.1.1 Single Spindle
    - 2.1.2.1.3.1.2 Multiple Spindle
  - 2.1.2.1.3.2 Vertical Chucking Machine
    - 2.1.2.1.3.2.1 Single Spindle
    - 2.1.2.1.3.2.2 Multiple Spindle

- 2.1.2.2 Shaping
  - 2.1.2.2.1 Horizontal Shaping
    - 2.1.2.2.1.1 Plain Shaper
    - 2.1.2.2.1.2 Universal Shaper
    - 2.1.2.2.1.3 Draw Cut Shaper
    - 2.1.2.2.1.4 Travelling Head Shaper
    - 2.1.2.2.1.5 Double Head Shaper
  - 2.1.2.2.2 Vertical Shaping
- 2.1.2.3 Planing
  - 2.1.2.3.1 Double Housing Planing
  - 2.1.2.3.2 Open Side Planing
  - 2.1.2.3.3 Plate Planing
- 2.1.2.4 Drilling
  - 2.1.2.4.1 Standard Upright Drilling
  - 2.1.2.4.2 Bench Drilling
  - 2.1.2.4.3 Sensitive Drilling
  - 2.1.2.4.4 Multiple Spindle Drilling
  - 2.1.2.4.5 Gank Drilling
  - 2.1.2.4.6 Turret Drilling

  - 2.1.2.4.7 Radial Drilling
  - 2.1.2.4.8 Deep Hole Drilling
  - 2.1.2.4.9 Gun Drilling
  - 2.1.2.4.10 Trepanning
- 2.1.2.5 Boring
  - 2.1.2.5.1 Horizontal Boring
    - 2.1.2.5.1.1 Table-Type Hor. Boring
    - 2.1.2.5.1.2 Floor-Type Hor. Boring
  - 2.1.2.5.2 Vertical Boring
  - 2.1.2.5.3 Jig Boring
- 2.1.2.6 Milling
  - 2.1.2.6.1 Knee and Column Milling
    - 2.1.2.6.1.1 Plain Milling
      - 2.1.2.6.1.1.1 Plain Horizontal Milling
      - 2.1.2.6.1.1.2 Plain Vertical Milling
    - 2.1.2.6.1.2 Universal Milling
  - 2.1.2.6.2 Ram Type Milling
  - 2.1.2.6.3 Bed-Type Milling
  - 2.1.2.6.4 Profiling-Type Milling
  - 2.1.2.6.5 Planer-Type Milling
  - 2.1.2.6.6 Thread Milling
  - 2.1.2.6.7 Hand Milling
  - 2.1.2.6.8 Skin Milling
- 2.1.2.7 Broaching
  - 2.1.2.7.1 Push Broaching
  - 2.1.2.7.2 Pull Broaching
  - 2.1.2.7.3 Surface Broaching
  - 2.1.2.7.4 Horizontal Continuous Surface Broaching
- 2.1.2.8 Sawing
  - 2.1.2.8.1 Hand Sawing
  - 2.1.2.8.2 Band Sawing
    - 2.1.2.8.2.1 Toothed Band Sawing
    - 2.1.2.8.2.2 Friction Band Sawing
  - 2.1.2.8.3 Circular Sawing
- 2.1.2.9 Abrading
  - 2.1.2.9.1 Grinding
    - 2.1.2.9.1.1 Precision Grinding
      - 2.1.2.9.1.1.1 Cylindrical Center Type
        - 2.1.2.9.1.1.1.1 Plain Center Type
        - 2.1.2.9.1.1.1.2 Universal Center Type

2.1.2.9.1.1.2 Centerless Grinding
2.1.2.9.1.1.2.1 Thru-Feed Centerless
2.1.2.9.1.1.2.2 In-Feed Centerless
2.1.2.9.1.1.2.3 End-Feed Centerless
2.1.2.9.1.1.3 Chucking Grinding
2.1.2.9.1.1.4 Internal Grinding
2.1.2.9.1.1.4.1 Plain Internal
2.1.2.9.1.1.4.2 Universal Internal
2.1.2.9.1.1.4.3 Centerless Internal
2.1.2.9.1.1.4.4 Planetary Internal
2.1.2.9.1.1.5 Disk Grinding
2.1.2.9.1.1.6 Thread Grinding
2.1.2.9.1.1.7 Cam Grinding
2.1.2.9.1.1.8 Crankshaft Grinding
2.1.2.9.1.1.9 Ultrasonic Grinding
2.1.2.9.1.1.10 Electro-Chemical Grinding
2.1.2.9.1.1.11 Surface Grinding
2.1.2.9.1.1.11.1 Horizontal Spindle Surface Grinding
2.1.2.9.1.1.11.1.1 Reciprocating Table
2.1.2.9.1.1.11.1.2 Rotary Table
2.1.2.9.1.1.11.2 Vertical Spindle Surface Grinding
2.1.2.9.1.1.11.2.1 Reciprocating Table
2.1.2.9.1.1.11.2.2 Rotary Table
2.1.2.9.1.2 Non-Precision Grinding
2.1.2.9.1.2.1 Belt Grinding
2.1.2.9.1.2.2 Bench-Floor Stand Grinding
2.1.2.9.1.2.3 Flexible Shaft Grinding
2.1.2.9.1.2.4 Electro-Chemical Grinding
2.1.2.9.1.2.5 Abrasive Cut-Off

  - 2.1.2.9.2 Finishing
    - 2.1.2.9.2.1 Precision Finishing
      - 2.1.2.9.2.1.1 Abrasive Belt Finishing
      - 2.1.2.9.2.1.2 Honing
      - 2.1.2.9.2.1.3 Lapping
      - 2.1.2.9.2.1.4 Hand Scraping
      - 2.1.2.9.2.1.5 Superfinishing
    - 2.1.2.9.2.2 Non-Precision Finishing
      - 2.1.2.9.2.2.1 Abrasive Belt Finishing
      - 2.1.2.9.2.2.2 Blasting
      - 2.1.2.9.2.2.3 Brushing
      - 2.1.2.9.2.2.4 Buffing
      - 2.1.2.9.2.2.5 Polishing
      - 2.1.2.9.2.2.6 Scaling
      - 2.1.2.9.2.2.7 Spalling
      - 2.1.2.9.2.2.8 Tumbling
      - 2.1.2.9.2.2.9 Ultrasonic Cleaning
- 2.1.2.10 Shearing
  - 2.1.2.10.1 Blanking
  - 2.1.2.10.2 Punching or Piercing
  - 2.1.2.10.3 Slotting
  - 2.1.2.10.4 Perforating
  - 2.1.2.10.5 Notching
  - 2.1.2.10.6 Slitting
  - 2.1.2.10.7 Lancing
  - 2.1.2.10.8 Nibbling
- 2.1.2.11 Etching
  - 2.1.2.11.1 Photo-Etching
  - 2.1.2.11.2 Chemical Milling
- 2.1.2.12 Burning
  - 2.1.2.12.1 Laser Burning
  - 2.1.2.12.2 Electrical Discharge Cutting
  - 2.1.2.12.3 Electric Arc Cutting
  - 2.1.2.12.4 Gas Cutting
    - 2.1.2.12.4.1 Oxy-Acetylene Cutting
    - 2.1.2.12.4.2 Powder Cutting
  - 2.1.2.12.5 Solar Energy Cutting
- 2.1.2.13 Clearing
  - 2.1.2.13.1 Blasting
  - 2.1.2.13.2 Chopping
  - 2.1.2.13.3 Digging
  - 2.1.2.13.4 Grubbing
  - 2.1.2.13.5 Scraping
  - 2.1.2.13.6 Igniting

2.2 Combining

2.2.1 Mixing
2.2.1.1 Beating
2.2.1.1.1 Agitator Beating
2.2.1.1.1.1 Paddle
2.2.1.1.1.1.1 Flat
2.2.1.1.1.1.2 Pitched
2.2.1.1.1.2 Gate
2.2.1.1.1.3 Anchor
2.2.1.1.1.4 Double Action
2.2.1.1.2 Turbine Imbeller Beating
2.2.1.1.2.1 Blade
2.2.1.1.2.2 Disc
2.2.1.1.2.3 Radial
2.2.1.1.2.4 Cone
2.2.1.2 Blending
2.2.1.2.1 Miscible Fluid Blending
2.2.1.2.2 Immiscible Liquid Blending
2.2.1.2.3 Emulsification Blending
2.2.1.2.4 Solid Suspension Blending
2.2.1.2.5 Agitation Blending
2.2.1.2.5.1 Gases
2.2.1.2.5.2 Liquids
2.2.1.2.5.3 Heat Transfer
2.2.1.3 Kneading
2.2.1.3.1 Batching Kneading
2.2.1.3.1.1 Internal
2.2.1.3.1.2 Open Trough
2.2.1.3.2 Continuous Kneading
2.2.1.4 Masticating
2.2.1.5 Impregnating
2.2.2 Coating
2.2.2.1 Spraying (and Vaporizing)
2.2.2.1.1 Atomizing Liquids
2.2.2.1.1.1 Air
2.2.2.1.1.2 Mechanical Pressure
2.2.2.1.1.3 Electrostatically
2.2.2.1.1.3.1 Nozzle-grid
2.2.2.1.1.3.2 Centrifugal Principle
2.2.2.1.2 Metal Spraying
2.2.2.1.2.1 Low-Temp. Melting Metals (venturi action)
2.2.2.1.2.1.1 Lead-tin solders
2.2.2.1.2.2 Medium-Temp. Melting Metals (Schooping gun)
2.2.2.1.2.2.1 Copper
2.2.2.1.2.2.2 Steel

- 2.2.2.1.2.3 High-Temp. Melting Metals (Plasma Arc Torch)
  - 2.2.2.1.2.3.1 Tungsten
  - 2.2.2.1.2.3.2 Molybdenum
  - 2.2.2.1.2.3.3 Refractory oxides
  - 2.2.2.1.2.3.4 Nitrides
  - 2.2.2.1.2.3.5 Carbides
- 2.2.2.1.3 Metal-Vapor Plating
  - 2.2.2.1.3.1 Vacuum Chamber Methods
    - 2.2.2.1.3.1.1 Evaporation
    - 2.2.2.1.3.1.2 Sublimation
  - 2.2.2.1.3.2 Atmospheric Heating
  - 2.2.2.1.3.3 Pyrolysis
  - 2.2.2.1.3.4 Sputtering
- 2.2.2.2 Brushing
- 2.2.2.3 Rolling
- 2.2.2.4 Dipping
  - 2.2.2.4.1 Hot Dipping
  - 2.2.2.4.2 Galvanizing
  - 2.2.2.4.3 Tin "Plating"
  - 2.2.2.4.4 Terne Coating
- 2.2.2.5 Printing
  - 2.2.2.5.1 Relief Printing
  - 2.2.2.5.2 Intaglio Printing
  - 2.2.2.5.3 Lithographic Printing
  - 2.2.2.5.4 Rotogravue Printing
  - 2.2.2.5.5 Photo-Gelatine Printing
  - 2.2.2.5.6 Photo-Copy Printing
  - 2.2.2.5.7 Silk Screen Printing
  - 2.2.2.5.8 Memo Printing
  - 2.2.2.5.9 Spirit Printing
  - 2.2.2.5.10 Transfer Printing
    - 2.2.2.5.9.1 Decal
- 2.2.2.6 Dyeing
  - 2.2.2.6.1 Electrolyte Dyeing
  - 2.2.2.6.2 Level Dyeing
  - 2.2.2.6.3 Diazotizing Dyeing
  - 2.2.2.6.4 Developing Dyeing
  - 2.2.2.6.5 Pigment Dyeing
  - 2.2.2.6.6 Dope or Spin Dyeing
- 2.2.2.7 Calendar Coating
- 2.2.2.8 Electrodeposition
  - 2.2.2.8.1 Electroplating
    - 2.2.2.8.1.1 Aqueous Solutions
    - 2.2.2.8.1.2 Salt Baths
    - 2.2.2.8.1.3 Organic Electrolytes

    - 2.2.2.9 Oxide Coating
      - 2.2.2.9.1 Anodizing
    - 2.2.2.10 Enamelling
      - 2.2.2.10.1 Vitreous (fired and fused, e.g., porcelain)
      - 2.2.2.10.2 Non-Vitreous (paints)
    - 2.2.2.11 Spreading
      - 2.2.2.11.1 Seeding
      - 2.2.2.11.2 Fertilizing
      - 2.2.2.11.3 Chemical Treating
    - 2.2.2.12 Sodding
  - 2.2.3 Assembling
    - 2.2.3.1 Positioning
      - 2.2.3.1.1 Locating
      - 2.2.3.1.2 Orienting
    - 2.2.3.2 Fastening
      - 2.2.3.2.1 Winding
      - 2.2.3.2.2 Spinning
      - 2.2.3.2.3 Laminating
      - 2.2.3.2.4 Felting
      - 2.2.3.2.5 Warping
      - 2.2.3.2.6 Braiding
      - 2.2.3.2.7 Weaving
      - 2.2.3.2.8 Welding
      - 2.2.3.2.9 Brazing and Soldering
      - 2.2.3.2.10 Pinning
      - 2.2.3.2.11 Sewing
      - 2.2.3.2.12 Seaming and Curling
      - 2.2.3.2.13 Shrinking
      - 2.2.3.2.14 Pressing
      - 2.2.3.2.15 Bonding
      - 2.2.3.2.16 Clipping
      - 2.2.3.2.17 Tying

- **2.3** Forming

  - 2.3.1 Working
    - 2.3.1.1 Peening
      - 2.3.1.1.1 Shot Peening (finishing process)
      - 2.3.1.1.2 Press Peening
      - 2.3.1.1.3 Impact Peening
    - 2.3.1.2 Rolling
      - 2.3.1.2.1 Continuous Rolling (Milling)
      - 2.3.1.2.2 Ingot or Hot Rolling (Bloom Rolling) (Sendzimir Rolling)
      - 2.3.1.2.3 Cold Rolling

    - 2.3.1.2.4 Pierce Rolling
    - 2.3.1.2.5 Tube or Strip Rolling
    - 2.3.1.2.6 Cold Powder Spin Rolling
    - 2.3.1.2.7 Compacting
- 2.3.1.3 Drawing
    - 2.3.1.3.1 Cold Drawing
    - 2.3.1.3.2 Tube Drawing
    - 2.3.1.3.3 Silver Drawing
    - 2.3.1.3.4 Shell Drawing
- 2.3.1.4 Pressing
    - 2.3.1.4.1 Cold Pressing
    - 2.3.1.4.2 Hot Pressing
    - 2.3.1.4.3 Finish Pressing (textile)
- 2.3.1.5 Forging
    - 2.3.1.5.1 Hammer Forging
    - 2.3.1.5.2 Drop Forging
    - 2.3.1.5.3 Impact Forging
    - 2.3.1.5.4 Press Forging
    - 2.3.1.5.5 Upset Forging
    - 2.3.1.5.6 Roll Forging
    - 2.3.1.5.7 Swag Forging
    - 2.3.1.5.8 Cold Head Forging
- 2.3.1.6 Stamping
    - 2.3.1.6.1 Rupture Stamping
        - 2.3.1.6.1.1 Blanking
        - 2.3.1.6.1.2 Piercing
        - 2.3.1.6.1.3 Cutting Off
        - 2.3.1.6.1.4 Lancing
    - 2.3.1.6.2 Non-Rupture Stamping
        - 2.3.1.6.2.1 Drawing
        - 2.3.1.6.2.2 Bending
        - 2.3.1.6.2.3 Embossing
- 2.3.1.7 Bending
    - 2.3.1.7.1 Die Bending
    - 2.3.1.7.2 Roller Bending
    - 2.3.1.7.3 Press Bending
    - 2.3.1.7.4 Wiper Bending
    - 2.3.1.7.5 Wrap Form Bending
    - 2.3.1.7.6 Spin Bending
    - 2.3.1.7.7 Squeeze Bending
    - 2.3.1.7.8 Press Brake Bending
- 2.3.1.8 Extruding
    - 2.3.1.8.1 Hot Extruding
    - 2.3.1.8.2 Cold Extruding
        - 2.3.1.8.2.1 Backward
        - 2.3.1.8.2.2 Forward
    - 2.3.1.8.3 Thick Mud Extruding

    - 2.3.1.8.4 Slot-Die Extruding
    - 2.3.1.8.5 Inflated Tube Extruding
  - 2.3.1.9 Metal Spinning
    - 2.3.1.9.1 Curl Metal Spinning
    - 2.3.1.9.2 Smooth Metal Spinning
    - 2.3.1.9.3 Shape Metal Spinning
    - 2.3.1.9.4 Neck Metal Spinning
    - 2.3.1.9.5 Bulge Metal Spinning
    - 2.3.1.9.6 Burnish Metal Spinning
    - 2.3.1.9.7 Bead Metal Spinning
  - 2.3.1.10 Molding (plastics)
    - 2.3.1.10.1 Compression (cold-hot)
    - 2.3.1.10.2 Transfer
    - 2.3.1.10.3 Injection
    - 2.3.1.10.4 Lamination
    - 2.3.1.10.5 Extrusion
  - 2.3.1.11 Vacuum Forming (plastics)
    - 2.3.1.11.1 Cavity Type Mold
    - 2.3.1.11.2 Force Above Sheet
    - 2.3.1.11.3 Force Below Sheet
  - 2.3.1.12 Pounding
    - 2.3.1.12.1 Hammering
    - 2.3.1.12.2 Tamping

- 2.3.2 Thermal Conditioning

  - 2.3.2.1 Curing
    - 2.3.2.1.1 Preserving (salting, smoking, drying)
    - 2.3.2.1.2 Setting (vulcanizing, etc.)
  - 2.3.2.2 Crystallizing
    - 2.3.2.2.1 Supersaturation
    - 2.3.2.2.2 Seeding (nucleation)
    - 2.3.2.2.3 Evaporization
    - 2.3.2.2.4 Cooling
  - 2.3.2.3 Casting
    - 2.3.2.3.1 Sand Casting
      - 2.3.2.3.1.1 Green Molds
      - 2.3.2.3.1.2 Dry-Sand Molds
      - 2.3.2.3.1.3 Shell Molding
    - 2.3.2.3.2 Permanent-Mold Casting (metal molds)
    - 2.3.2.3.3 Die Casting
      - 2.3.2.3.3.1 Piston
      - 2.3.2.3.3.2 Cold-Chamber Machine
    - 2.3.2.3.4 Investment Casting (wax)
    - 2.3.2.3.5 Plaster Mold Casting
    - 2.3.2.3.6 Centrifugal Casting

            - 2.3.2.3.6.1 True Centrifugal Casting
            - 2.3.2.3.6.2 Semi-Centrifugal Casting
            - 2.3.2.3.6.3 Centrifuged Casting
    - 2.3.2.4 Vacuum Depositing (See metal-vapor plating)

    - 2.3.2.5 Heat Treating
        - 2.3.2.5.1 Non-ferrous Metals and Alloys
            - 2.3.2.5.1.1 Annealing
            - 2.3.2.5.1.2 Stress Relieving
            - 2.3.2.5.1.3 Heating for Homogenization
            - 2.3.2.5.1.4 Hardening
        - 2.3.2.5.2 Steels
            - 2.3.2.5.2.1 Annealing
            - 2.3.2.5.2.2 Normalizing
            - 2.3.2.5.2.3 Hardening
            - 2.3.2.5.2.4 Tempering
        - 2.3.2.5.3 Glass Products
            - 2.3.2.5.3.1 Annealing
            - 2.3.2.5.3.2 Tempering
    - 2.3.2.6 Melting
        - 2.3.2.6.1 Metallurgical Furnaces
            - 2.3.2.6.1.1 Fuel Fired
                - 2.3.2.6.1.1.1 Crucible
                - 2.3.2.6.1.1.2 Metal Pot
                - 2.3.2.6.1.1.3 Reverberatory
                - 2.3.2.6.1.1.4 Open Hearth
                - 2.3.2.6.1.1.5 Cupola
            - 2.3.2.6.1.2 Electric
                - 2.3.2.6.1.2.1 Arc Type
                - 2.3.2.6.1.2.2 Induction Type
    - 2.3.2.7 Freezing (see heat transfer)
        - 2.3.2.7.1 Evaporation Processes (many kinds)
        - 2.3.2.7.2 Conduction (contact- momentum)
        - 2.3.2.7.3 Convection (fluids)
        - 2.3.2.7.4 Radiation
    - 2.3.2.8 Chilling

- 2.3.3 Combing

- 2.3.4 Winding

- 2.3.5 Knitting

- 2.3.6 Displacing
    - 2.3.6.1 Bulldozing
    - 2.3.6.2 Disassembling

2.3.6.3 Grading
2.3.6.4 Plowing
2.3.6.5 Ripping
2.3.6.6 Scarifying
2.3.6.7 Wrecking

3. Post-Processing

3.1 Altering

3.2 Installing

3.3 Maintaining

3.4 Repairing

While the foregoing outline of production technology seems to be quite extensive, a fuller appreciation of the scope of this body of knowledge may be gained from a partial expansion of one element of the outline in the direction of increased specificity. To illustrate the magnitude of this taxonomy, one of the fastening processes, welding, (at the seventh level of specificity in production technology), has been expanded two additional levels and is presented below:

2.2.3.2.8 Welding

- 2.2.3.2.8.1 Fusion Welding
    - 2.2.3.2.8.1.1 Flow Welding
    - 2.2.3.2.8.1.2 Induction Welding
    - 2.2.3.2.8.1.3 Friction Welding
    - 2.2.3.2.8.1.4 Explosive Welding
    - 2.2.3.2.8.1.5 Ultrasonic Welding
    - 2.2.3.2.8.1.6 Electron Beam Welding
    - 2.2.3.2.8.1.7 Laser Welding
    - 2.2.3.2.8.1.8 Cold Pressure Welding

- 2.2.3.2.8.2 Forge Welding
    - 2.2.3.2.8.2.1 Hammer Welding
    - 2.2.3.2.8.2.2 Die Welding
    - 2.2.3.2.8.2.3 Roll Welding

- 2.2.3.2.8.3 Thermit Welding
    - 2.2.3.2.8.3.1 Pressure Thermit Welding
    - 2.2.3.2.8.3.2 Nonpressure Thermit Welding

- 2.2.3.2.8.4 Gas Welding
    - 2.2.3.2.8.4.1 Oxyacetylene Welding
    - 2.2.3.2.8.4.2 Airacetylene Welding
    - 2.2.3.2.8.4.3 Oxyhydrogen Welding
    - 2.2.3.2.8.4.4 Gas Pressure Welding
    - 2.2.3.2.8.4.5 Powder Gas Welding

- 2.2.3.2.8.5 Resistance Welding
    - 2.2.3.2.8.5.1 Spot Welding
    - 2.2.3.2.8.5.2 Seam-Roll-Spot-Welding
    - 2.2.3.2.8.5.3 Flash Welding
    - 2.2.3.2.8.5.4 Upset Welding
    - 2.2.3.2.8.5.5 Projection Welding
    - 2.2.3.2.8.5.6 Percussion Welding

- 2.2.3.2.8.6 Arc Welding
    - 2.2.3.2.8.6.1 Bare Metal Electrode Arc Welding
    - 2.2.3.2.8.6.2 Flux Shielded Metal Electrode Arc Welding
    - 2.2.3.2.8.6.3 Impregnated Tape Welding
    - 2.2.3.2.8.6.4 Unshielded Single Carbon Arc Welding
    - 2.2.3.2.8.6.5 Unshielded Twin Carbon Arc Welding
    - 2.2.3.2.8.6.6 Inert Gas Shielded Carbon Arc Welding
    - 2.2.3.2.8.6.7 Reactive Gas Shielded Carbon Arc Welding
    - 2.2.3.2.8.6.8 Flux Shielded Carbon Arc Welding
    - 2.2.3.2.8.6.9 Atomic Hydrogen Welding
    - 2.2.3.2.8.6.10 Submerged Arc Welding
    - 2.2.3.2.8.6.11 Electroslag Welding
    - 2.2.3.2.8.6.12 Electrogas Welding
    - 2.2.3.2.8.6.13 Plasma Arc Welding
    - 2.2.3.2.8.6.14 Inert Gas Shielded Tungsten Arc Welding
    - 2.2.3.2.8.6.15 Reactive Gas Shielded Tungsten Arc Welding
    - 2.2.3.2.8.6.16 Inert Gas Shielded Metal Arc Welding

2.2.3.2.8.6.17 Reactive Gas Shielded Metal Arc Welding
2.2.3.2.8.6.18 Flux Shielded Metal Arc Welding
2.2.3.2.8.6.19 Flux-Gas Shielded Metal Arc Welding
2.2.3.2.8.6.20 Unshielded Stud Welding
2.2.3.2.8.6.21 Inert Gas Shielded Stud Welding
2.2.3.2.8.6.22 Flux Shielded Stud Welding

III. INDUSTRIAL PERSONNEL TECHNOLOGY

The industrial technology which primarily affects humans is planned, organized, and controlled by management, and it also affects management. That is to say, the managers and production personnel all are affected by personnel technology. However, the specific technology may differ according to many different factors. Thus, an unskilled worker may be recruited in one way, and an engineer may be recruited in quite another, and they may be affected by differing fringe benefits. Also, recruiting in construction differs markedly from recruiting in manufacturing.

This technology is not only affected by the kinds of workers and establishments, it also is affected by the particular product and by in-plant and on-site differences. For example, certain specialized safety knowledge is required in the processing of radioactive materials. In addition, there is a difference in providing for personal needs in a typical factory and on a typical construction project. Despite the diversity in specific personnel practices, the knowledge of them can be structured.

The elements of personnel technology listed below do have a general sequential character. However, there are interrelationships and applications which do not conform to this pattern. For example, inadequate economic rewards will likely affect recruiting and selecting, and training may occur repeatedly in the career pattern of a worker.

Once again, it should be repeated that the following listed elements of personnel technology are artificially extracted from the operational setting for analytical purposes. In actuality, the managed men-material industrial production system is integrated.

1. Hiring
    1.1 Recruiting
        1.1.1 Disseminating vacancy notices
        1.1.2 Contacting employment agencies
        1.1.3 Making personal contacts
        1.1.4 Reimbursing interview costs
        1.1.5 Communicating advantages
    1.2 Selecting
        1.2.1 Testing
        1.2.2 Interviewing
        1.2.3 Obtaining and checking references
        1.2.4 Matching qualifications with work requirements
        1.2.5 Reporting results to applicants and management
    1.3 Inducting
        1.3.1 Appointing
        1.3.2 Reimbursing moving costs
        1.3.3 Establishing personnel record
        1.3.4 Distributing records to appropriate departments
        1.3.5 Orienting to work
        1.3.6 Answering employee questions
2. Training
    2.1 On the job training
        2.1.1 Apprenticing
        2.1.2 Interning
        2.1.3 Coaching
    2.2 Other training
        2.2.1 Conducting conferences and workshops
        2.2.2 Providing instructional materials
        2.2.3 Classroom instructing
        2.2.4 Sending to outside programs
3. Working
    3.1 Providing economic rewards
        3.1.1 Paying wages and salaries
        3.1.2 Providing fringe benefits

- 3.2 Providing physical setting
  - 3.2.1 Housekeeping
  - 3.2.2 Lighting
  - 3.2.3 Heating, cooling, and ventilating
  - 3.2.4 Controlling sound, vibration, and rhythm
  - 3.2.5 Coloring
  - 3.2.6 Posturing
  - 3.2.7 Protecting
  - 3.2.8 Meeting personal needs

- 3.3 Providing social environment
  - 3.3.1 Providing recreational activities
  - 3.3.2 Providing social programs
  - 3.3.3 Providing communication channels
  - 3.3.4 Structuring the work group
  - 3.3.5 Acting on surveys
  - 3.3.6 Disciplining
  - 3.3.7 Merit rating
  - 3.3.8 Giving service awards

4. Advancing

- 4.1 Promoting
  - 4.1.1 Reassigning upward
  - 4.1.2 Reclassifying upward

- 4.2 Demoting
  - 4.2.1 Reassigning downward
  - 4.2.2 Reclassifying downward

- 4.3 Discharging
  - 4.3.1 Separating
  - 4.3.2 Relocating
  - 4.3.3 Laying off

5. Retiring

- 5.1 Counseling
  - 5.1.1 Making pre-retirement plans
  - 5.1.2 Serving after retirement

- 5.2 Pre-retirement job engineering
  - 5.2.1 Reducing work load
  - 5.2.2 Increasing leisure time
  - 5.2.3 Changing worker function

5.3 Recognizing service
    5.3.1 Disseminating announcements
    5.3.2 Awarding mementos
    5.3.3 Holding recognition meetings
    5.3.4 Posting names of retirees

5.4 Awarding retirement benefits
    5.4.1 Making payments
    5.4.2 Providing fringe benefits

IV. INDUSTRIAL MATERIAL GOODS

Figure III, page 51, presents brief outlines of several major product classification systems and additional ones may be found in the Appendices. All the classification systems in Figure III include major classes named "contract construction" and "manufacturing" and therefore each could provide a basis for classifying industrial material goods as a composite of the two categories.

It is efficient for the Project to adopt the manufactured product classes based upon the Standard Industrial Classification Manual (Bureau of the Budget, 1957) because this structure has been adopted universally by federal agencies and because the 1963 Census of Manufactures and its Numerical List of Manufactured Products (U. S. Department of Commerce, 1963) is based upon it.

The Numerical List of Manufactured Products cited above provides an adequate structure of approximately 7,500 seven-digit product codes. It provides a classification system for the principal primary products of manufacturing based on the 1963 Census of Manufactures. In this publication products are listed in numerical order in product classes, these classes are grouped within establishment classes, and the establishment classes are ordered within S. I. C. establishment groups and subgroups.

An example of the above voluminous classification, in descending order of specificity, would place manufacturing within the major S. I. C. divisions of economic activity. "Furniture and Fixtures" is a two-digit group (25) within manufacturing (groups 19 through 49). "Household Furniture" is a three-digit subgroup (251) in group 25. "Wood Household Furniture" is a four-digit (2511) "breakdown" within subgroup 251. "Radio, Phonograph, and TV Wood Cabinets" is a further breakdown (25111) in the product code 2511. "Television Cabinets and Combinations" (2511115) is the final level of specificity in product code 25111.

While the S. I. C. and its product expansion in the Census of Manufactures provides an adequate classification system for the identification and ordering of manufactured material goods, no comparable development has occured in classifying constructed material goods. The subgroups in the S. I. C. construction division (building construction - general contractors, construction other than building construction - general contractors, and construction - special trade contractors) do not lead to product classes. For example, both general contractors and special trade contractors may contribute to a single product, so this classification provides a basis for collecting economic data but does not provide a basis for product classification.

Confronted with the lack of an adequate structure of the constructed material goods component of a structure of industrial material goods, the Project staff has adopted the Bureau of Census classification of constructed works which is used as a basis for reports on value of new construction and other product - related reports. At a generalized level, this classification system is generally used by the construction field and governmental agencies and is adequate for instructional purposes. At a more detailed level, it lacks internal consistency and is replaced by a classification system which is reported under construction technology.

The following product classifications have been identified as being adequate for instructional purposes:

1. Constructed material goods*
    - 1.1 Private
        - 1.1.1 Residential buildings (nonfarm)
            - 1.1.1.1 New housing units
            - 1.1.1.2 Additions and alterations
            - 1.1.1.3 Nonhousekeeping
        - 1.1.2 Nonresidential buildings
            - 1.1.2.1 Industrial
            - 1.1.2.2 Commercial
                - 1.1.2.2.1 Office buildings and warehouses
                - 1.1.2.2.2 Stores, restaurants, and garages
            - 1.1.2.3 Other nonresidential buildings
                - 1.1.2.3.1 Religious
                - 1.1.2.3.2 Educational
                - 1.1.2.3.3 Hospital and institutional
                - 1.1.2.3.4 Social and recreational
                - 1.1.2.3.5 Miscellaneous
        - 1.1.3 Farm construction
            - 1.1.3.1 Operator dwellings
            - 1.1.3.2 Other farm construction
        - 1.1.4 Public utilities
            - 1.1.4.1 Telephone and telegraph
            - 1.1.4.2 Other public utilities
                - 1.1.4.2.1 Railroads
                - 1.1.4.2.2 Electric light and power
                - 1.1.4.2.3 Gas
                - 1.1.4.2.4 Petroleum pipelines
        - 1.1.5 All other private

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* From Department of Commerce, Bureau of the Census, *Construction Reports*.

- 1.2 Public
  - 1.2.1 Residential buildings
  - 1.2.2 Nonresidential buildings
    - 1.2.2.1 Industrial
    - 1.2.2.2 Educational
    - 1.2.2.3 Hospital and institutional
    - 1.2.2.4 Administrative and service
    - 1.2.2.5 Other nonresidential buildings
  - 1.2.3 Military facilities
  - 1.2.4 Highways
  - 1.2.5 Sewer and water systems
    - 1.2.5.1 Sewer
    - 1.2.5.2 Water
  - 1.2.6 Public service enterprises
  - 1.2.7 Conservation and development
  - 1.2.8 All other public

2. Manufactured Material Goods*

- 2.1 Ordnance and Accessories
  - 2.1.1 Guns, Howitzers, Mortars, and Related Equipment
  - 2.1.2 Ammunition, Except for Small Arms
  - 2.1.3 Tanks and Tank Components
  - 2.1.4 Sighting and Fire Control Equipment
  - 2.1.5 Small Arms
  - 2.1.6 Small Arms Ammunition
  - 2.1.7 Ordnance and Accessories, not Elsewhere Classified

- 2.2 Food and Kindred Products
  - 2.2.1 Meat Products
  - 2.2.2 Dairy Products
  - 2.2.3 Canning and Preserving Fruits, Vegetables, and Sea Foods
  - 2.2.4 Grain Mill Products
  - 2.2.5 Bakery Products
  - 2.2.6 Sugar
  - 2.2.7 Confectionery and Related Products
  - 2.2.8 Beverage Industries
  - 2.2.9 Miscellaneous Food Preparations and Kindred Products

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* From Department of Commerce, Bureau of the Budget, Standard Industrial Classification Manual.

- 2.3 Tobacco Manufactures
  - 2.3.1 Cigarettes
  - 2.3.2 Cigars
  - 2.3.3 Tobacco (Chewing and Smoking) and Snuff
  - 2.3.4 Tobacco Stemming and Redrying

- 2.4 Textile Mill Products
  - 2.4.1 Broad Woven Fabric Mills, Cotton
  - 2.4.2 Broad Woven Fabric Mills, Man-Made Fiber and Silk
  - 2.4.3 Broad Woven Fabric Mills, Wool: Including Dyeing and Finishing
  - 2.4.4 Narrow Fabrics and Other Smallwares Mills: Cotton, Wool, Silk, and Man-Made Fiber
  - 2.4.5 Knitting Mills
  - 2.4.6 Dyeing and Finishing Textiles, Except Wool Fabrics and Knit Goods
  - 2.4.7 Floor Covering Mills
  - 2.4.8 Yarn and Thread Mills
  - 2.4.9 Miscellaneous Textile Goods

- 2.5 Apparel and Other Finished Products Made From Fabrics and Similar Materials
  - 2.5.1 Men's, Youths', and Boys' Suits, Coats, and Overcoats
  - 2.5.2 Men's, Youths', and Boys' Furnishings, Work Clothing and Allied Garments
  - 2.5.3 Women's, Misses', and Juniors' Outerwear
  - 2.5.4 Women's, Misses', Children's, and Infants' Under Garments
  - 2.5.5 Hats, Caps, and Millinery
  - 2.5.6 Girls', Children's, and Infants' Outerwear
  - 2.5.7 Fur Goods
  - 2.5.8 Miscellaneous Apparel and Accessories
  - 2.5.9 Miscellaneous Fabricated Textile Products

- 2.6 Lumber and Wood Products, Except Furniture
  - 2.6.1 Logging Camps and Logging Contractors
  - 2.6.2 Sawmills and Planing Mills
  - 2.6.3 Millwork, Veneer, Plywood, and Prefabricated Structural Wood Products
  - 2.6.4 Wooden Containers
  - 2.6.5 Miscellaneous Wood Products

- 2.7 Furniture and Fixtures
  - 2.7.1 Household Furniture
  - 2.7.2 Office Furniture
  - 2.7.3 Public Building and Related Furniture
  - 2.7.4 Partitions, Shelving, Lockers, and Office and Store Fixtures
  - 2.7.5 Miscellaneous Furniture and Fixtures

2.8 Paper and Allied Products
  2.8.1 Pulp Mills
  2.8.2 Paper Mills, Except Building Paper Mills
  2.8.3 Paperboard Mills
  2.8.4 Converted Paper and Paperboard Products, Except Containers and Boxes
  2.8.5 Paperboard Containers and Boxes
  2.8.6 Building Paper and Building Board Mills

2.9 Printing, Publishing, and Allied Industries
  2.9.1 Newspapers: Publishing, Publishing and Printing
  2.9.2 Periodicals: Publishing, Publishing and Printing
  2.9.3 Books
  2.9.4 Miscellaneous Publishing
  2.9.5 Commercial Printing
  2.9.6 Manifold Business Forms Manufacturing
  2.9.7 Greeting Card Manufacturing
  2.9.8 Bookbinding and Related Industries
  2.9.9 Service Industries for the Printing Trade

2.10 Chemicals and Allied Products
  2.10.1 Industrial Inorganic and Organic Chemicals
  2.10.2 Plastics Materials and Synthetic Resins, Synthetic Rubber, Synthetic and Other Man-Made Fibers, Except Glass
  2.10.3 Drugs
  2.10.4 Soap, Detergents and Cleaning Preparations, Perfumes, Cosmetics, and Other Toilet Preparations
  2.10.5 Paints, Varnishes, Lacquers, Enamels, and Allied Products
  2.10.6 Gum and Wood Chemicals
  2.10.7 Agricultural Chemicals
  2.10.8 Miscellaneous Chemical Products

2.11 Petroleum Refining and Related Industries
  2.11.1 Petroleum Refining
  2.11.2 Paving and Roofing Materials
  2.11.3 Miscellaneous Products of Petroleum and Coal

2.12 Rubber and Miscellaneous Plastics Products.
  2.12.1 Tires and Inner Tubes
  2.12.2 Rubber Footwear
  2.12.3 Reclaimed Rubber
  2.12.4 Fabricated Rubber Products, Not Elsewhere Classified
  2.12.5 Miscellaneous Plastic Products

2.13 Leather and Leather Products
  - 2.13.1 Leather Tanning and Finishing
  - 2.13.2 Industrial Leather Belting and Packing
  - 2.13.3 Boot and Shoe Cut Stock and Findings
  - 2.13.4 Footwear, Except Rubber
  - 2.13.5 Leather Gloves and Mittens
  - 2.13.6 Luggage
  - 2.13.7 Handbags and Other Personal Leather Goods
  - 2.13.8 Leather Goods, Not Elsewhere Classified

2.14 Stone, Clay, and Glass Products
  - 2.14.1 Flat Glass
  - 2.14.2 Glass and Glassware, Pressed or Blown
  - 2.14.3 Glass Products, Made of Purchased Glass
  - 2.14.4 Cement, Hydraulic
  - 2.14.5 Structural Clay Products
  - 2.14.6 Pottery and Related Products
  - 2.14.7 Concrete, Gypsum, and Plaster Products
  - 2.14.8 Cut Stone and Stone Products
  - 2.14.9 Abrasive, Asbestos, and Miscellaneous Nonmetallic Mineral Products

2.15 Primary Metal Industries
  - 2.15.1 Blast Furnaces, Steel Works, and Rolling and Finishing Mills
  - 2.15.2 Iron and Steel Foundries
  - 2.15.3 Primary Smelting and Refining of Nonferrous Metals
  - 2.15.4 Secondary Smelting and Refining of Nonferrous Metals and Alloys
  - 2.15.5 Rolling, Drawing and Extruding of Nonferrous Metals
  - 2.15.6 Nonferrous Foundries
  - 2.15.7 Miscellaneous Primary Metal Industries

2.16 Fabricated Metal Products, Except Ordnance, Machinery, and Transportation Equipment
  - 2.16.1 Metal Cans
  - 2.16.2 Cutlery, Hand Tools, and General Hardware
  - 2.16.3 Heating Apparatus (Except Electric) and Plumbing Fixtures
  - 2.16.4 Fabricated Structural Metal Products
  - 2.16.5 Screw Machine Products, and Bolts, Nuts, Screws, Rivets and Washers
  - 2.16.6 Metal Stampings
  - 2.16.7 Coating, Engraving, and Allied Services
  - 2.16.8 Miscellaneous Fabricated Wire Products
  - 2.16.9 Miscellaneous Fabricated Metal Products

- 2.17 Machinery, Except Electrical
  - 2.17.1 Engines and Turbines
  - 2.17.2 Farm Machinery and Equipment
  - 2.17.3 Construction, Mining, and Materials Handling Machinery and Equipment
  - 2.17.4 Metalworking Machinery and Equipment
  - 2.17.5 Special Industry Machinery, Except Metalworking Machinery
  - 2.17.6 General Industrial Machinery and Equipment
  - 2.17.7 Office, Computing and Accounting Machines
  - 2.17.8 Service Industry Machines
  - 2.17.9 Miscellaneous Machinery, Except Electrical

- 2.18 Electrical Machinery, Equipment, and Supplies
  - 2.18.1 Electric Transmission and Distribution Equipment
  - 2.18.2 Electrical Industrial Apparatus
  - 2.18.3 Household Appliances
  - 2.18.4 Electric Lighting and Wiring Equipment
  - 2.18.5 Radio and Television Receiving Sets, Except Communication Types
  - 2.18.6 Communication Equipment
  - 2.18.7 Electronic Components and Accessories
  - 2.18.8 Miscellaneous Electrical Machinery, Equipment, and Supplies

- 2.19 Transportation Equipment
  - 2.19.1 Motor Vehicles and Motor Vehicle Equipment
  - 2.19.2 Aircraft and Parts
  - 2.19.3 Ship and Boat Building and Repairing
  - 2.19.4 Railroad Equipment
  - 2.19.5 Motorcycles, Bicycles, and Parts
  - 2.19.6 Miscellaneous Transportation Equipment

- 2.20 Professional, Scientific, and Controlling Instruments; Photographic and Optical Goods; Watches and Clocks
  - 2.20.1 Engineering, Laboratory, and Scientific and Research Instruments and Associated Equipment
  - 2.20.2 Instruments for Measuring, Controlling, and Indicating Physical Characteristics
  - 2.20.3 Optical Instruments and Lenses
  - 2.20.4 Surgical, Medical, and Dental Instruments and Supplies
  - 2.20.5 Ophthalmic Goods
  - 2.20.6 Photographic Equipment and Supplies
  - 2.20.7 Watches, Clocks, Clockwork Operated Devices, and Parts

2.21 Miscellaneous Manufacturing Industries
  2.21.1 Jewelry, Silverware, and Plated Ware
  2.21.2 Musical Instruments and Parts
  2.21.3 Toys, Amusement, Sporting and Athletic Goods
  2.21.4 Pens, Pencils, and other Office and Artists' Materials
  2.21.5 Costume Jewelry, Costume Novelties, Button, and Miscellaneous Notions, Except Precious Metal
  2.21.6 Miscellaneous Manufacturing Industries

The above classification of industrial material goods does not reflect that additional industrial production of economic value through post-processing, commonly equated with servicing. This is because the production of "industrial services" (services to material goods) is not classified or reported in any systematic or thorough manner.

If an automobile manufacturer adds value to a nonfunctioning unit by repairing or replacing faulty elements, after production and before shipping, this added value commonly is accounted for as a production cost. The production of an appliance repair department within a large department store is accounted for as an element of retail trade. The automotive alteration, installation, maintenance, and repair produced by Greyhound Lines, Incorporated, is classified as transportation.

A systematic classification of industrial production in the post-processing of industrial material goods could provide a valuable additional dimension of industrial production. Because existing universally adopted product classifications do not include this dimension, an extensive reconceptualization of the basic structure would be required to provide it. The scope of this task is beyond the capability of the time and staff of this

Project, if the goal of restructing the basis for reporting economic data would be judged desirable.

For the purposes of this Project, an adequate solution to the problem of accounting for the post-processing production of industry is to note that, in addition to material products, industry also produces economic value by altering, installing, maintaining, and repairing material goods; though data are lacking on the kind and scope of this facet of industrial production. It also should be noted that much of this added value is provided by the consumer, as in the case of the amateur auto mechanic or other "do-it-yourselfers."

V. Construction Technology

A. Construction Management Technology

The knowledge of how to manage construction efficiently is like in kind with industrial management technology. However, specialized knowledge is required for the industrial manager to function at a very detailed level in construction. While there are generalizable elements of industrial planning, efficient bridge planning differs in many specific ways from toothbrush planning. Similarly, but at a more detailed level, there are generalizable elements of industrial researching. However, the knowledge of how to take and interpret test cores for a bridge abutment differs in many specific ways from making and interpreting samples of toothbrush bristles.

At the more specific level of construction management technology, it is more meaningful to structure that knowledge in terms of the sequenced activities of construction management personnel rather than in terms of whether an activity relates to the more generalized classes of planning, organizing, and controlling. Thus, the subclasses under construction management technology become initiating, developing, and implementing the project.

Even within this framework the structure provides for the knowledge of how to manage all constructed works. The structure takes on greater operational significance when it is detailed in relationship to a particular construction project, such as a specific bridge. Then the knowledge can be identified which will efficiently initiate, develop, and implement that one project, and it is at this level that construction management technology is most distinct from the equally specific knowledge of manufacturing management technology and from the more generalized knowledge of industrial management technology.

1. Initiating the Project

- 1.1 Formulating
  - 1.1.1 Determining objectives
    - 1.1.1.1 Stating goals
    - 1.1.1.2 Consulting
      - 1.1.1.2.1 Selecting
      - 1.1.1.2.2 Commissioning
    - 1.1.1.3 Establishing project criteria
    - 1.1.1.4 Evaluating
    - 1.1.1.5 Describing objectives
  - 1.1.2 Researching
    - 1.1.2.1 Locating data
      - 1.1.2.1.1 Communicating
      - 1.1.2.1.2 Searching
    - 1.1.2.2 Retrieving data
      - 1.1.2.2.1 Surveying
        - 1.1.2.2.1.1 Measuring
        - 1.1.2.2.1.2 Counting
        - 1.1.2.2.1.3 Leveling
        - 1.1.2.2.1.4 Interviewing
        - 1.1.2.2.1.5 Photographing

1.1.2.2.2 Purchasing data
1.1.2.2.3 Borrowing data
1.1.2.3 Describing data
1.1.2.3.1 Drawing
1.1.2.3.2 Reporting
1.1.2.3.3 Classifying - catagorizing
1.1.2.3.4 Defining
1.1.2.4 Evaluating Data
1.1.2.4.1 Comparing
1.1.2.4.2 Contrasting
1.1.2.4.3 Measuring against criteria
1.1.2.4.4 Rating
1.1.2.5 Forecasting
1.1.2.5.1 Guessing - estimating
1.1.2.5.2 Projecting
1.1.2.5.3 Making mathematical models
1.2 Administrating the Project
1.2.1 Directing
1.2.1.1 Coordinating
1.2.1.2 Assigning
1.2.1.3 Supervising
1.2.1.4 Inspecting
1.2.2 Authorizing
1.2.2.1 Verifying
1.2.2.2 Certifying
1.2.2.3 Approving
1.2.2.4 Redefining
1.3 Project Programming
1.3.1 Evaluating
1.3.1.1 Analyzing data
1.3.1.1.1 Grouping
1.3.1.1.2 Classifying
1.3.1.1.3 Weighting
1.3.1.2 Comparing
1.3.1.3 Contrasting
1.3.2 Selecting
1.3.2.1 Examining
1.3.2.2 Eliminating
1.3.2.3 Adapting
1.3.2.4 Adopting
1.3.3 Presenting
1.3.3.1 Scheduling
1.3.3.1.1 Timing
1.3.3.1.2 Allocating
1.3.3.2 Diagramming
1.3.3.2.1 P.E.R.T'ing
1.3.3.2.2 Routing

        - 1.3.3.3 Reporting
        - 1.3.3.4 Demonstrating
        - 1.3.3.5 Summarizing
- 1.4 Financing the Project
  - 1.4.1 Appraising property
    - 1.4.1.1 Inspecting
    - 1.4.1.2 Recording
    - 1.4.1.3 Describing
    - 1.4.1.4 Analyzing
    - 1.4.1.5 Correlating
    - 1.4.1.6 Estimating
    - 1.4.1.7 Reporting
    - 1.4.1.8 Certifying
  - 1.4.2 Estimating probable costs (land + construction)
    - 1.4.2.1 Measuring
    - 1.4.2.2 Pricing
    - 1.4.2.3 Calculating
    - 1.4.2.4 Projecting
    - 1.4.2.5 Accounting
    - 1.4.2.6 Comparing
    - 1.4.2.7 Evaluating
  - 1.4.3 Funding
    - 1.4.3.1 Backing
      - 1.4.3.1.1 Consulting
      - 1.4.3.1.2 Contracting
    - 1.4.3.2 Capitalizing
    - 1.4.3.3 Mortgaging
    - 1.4.3.4 Borrowing
    - 1.4.3.5 Selling
    - 1.4.3.6 Purchasing
    - 1.4.3.7 Amortizing
    - 1.4.3.8 Incorporating
    - 1.4.3.9 Matching
  - 1.4.4 Documenting
    - 1.4.4.1 Describing
    - 1.4.4.2 Contracting
    - 1.4.4.3 Floating
    - 1.4.4.4 Legalizing
      - 1.4.4.4.1 Notarizing
      - 1.4.4.4.2 Defining
      - 1.4.4.4.3 Witnessing
      - 1.4.4.4.4 Signing
  - 1.4.5 Budgeting
    - 1.4.5.1 Allocating
    - 1.4.5.2 Timing

2. Developing the Project

- 2.1 Designing
  - 2.1.1 Evaluating Concepts
    - 2.1.1.1 Evaluating the program
      - 2.1.1.1.1 Examining functions and elements
      - 2.1.1.1.2 Weighting functions and elements
      - 2.1.1.1.3 Grouping functions and elements
      - 2.1.1.1.4 Supplementing the program
    - 2.1.1.2 Determining functional relationships
      - 2.1.1.2.1 Rationalizing
      - 2.1.1.2.2 Relating functions and elements
      - 2.1.1.2.3 Coordinating functions and elements
      - 2.1.1.2.4 Diagramming functional relationships
      - 2.1.1.2.5 Innovating
  - 2.1.2 Postulating Solutions
    - 2.1.2.1 Scaling functional relationships
      - 2.1.2.1.1 Measuring
      - 2.1.2.1.2 Delineating
      - 2.1.2.1.3 Adjusting
    - 2.1.2.2 Presenting solutions
      - 2.1.2.2.1 Drawing
      - 2.1.2.2.2 Reporting
  - 2.1.3 Selecting a solution
    - 2.1.3.1 Analyzing alternative solutions
      - 2.1.3.1.1 Qualifying
      - 2.1.3.1.2 Quantifying
    - 2.1.3.2 Appraising alternative solutions
      - 2.1.3.2.1 Comparing
      - 2.1.3.2.2 Contrasting
    - 2.1.3.3 Evaluating alternative solutions
      - 2.1.3.3.1 Weighting solutions
      - 2.1.3.3.2 Deciding and choosing
- 2.2 Engineering
  - 2.2.1 Interpreting drawings and reports
  - 2.2.2 Establishing detail design criteria and standards
  - 2.2.3 Analyzing problems - proposal
    - 2.2.3.1 Grouping
    - 2.2.3.2 Classifying
    - 2.2.3.3 Identifying
      - 2.2.3.3.1 Listing
      - 2.2.3.3.2 Coding
      - 2.2.3.3.3 Referencing
  - 2.2.4 Estimating sizes - capacities
    - 2.2.4.1 Referring (past experience)
    - 2.2.4.2 Comparing
    - 2.2.4.3 Approximating

- 2.2.5 Detail Designing
  - 2.2.5.1 Standardizing components - elements
  - 2.2.5.2 Computing
    - 2.2.5.2.1 Calculating
    - 2.2.5.2.2 Calibrating
    - 2.2.5.2.3 Appraising
  - 2.2.5.3 Experimenting
    - 2.2.5.3.1 Modeling
    - 2.2.5.3.2 Building prototypes
    - 2.2.5.3.3 Testing
      - 2.2.5.3.3.1 Recording
      - 2.2.5.3.3.2 Evaluating
  - 2.2.5.4 Preparing working drawings
    - 2.2.5.4.1 Scaling
    - 2.2.5.4.2 Dimensioning
    - 2.2.5.4.3 Notating
    - 2.2.5.4.4 Referencing and titling
  - 2.2.5.5 Securing approval
    - 2.2.5.5.1 Inspecting
    - 2.2.5.5.2 Authorizing
- 2.2.6 Specifying
  - 2.2.6.1 Preparing outline specification
    - 2.2.6.1.1 Sectioning
    - 2.2.6.1.2 Itemizing
    - 2.2.6.1.3 Describing
    - 2.2.6.1.4 Selecting
    - 2.2.6.1.5 Deciding
    - 2.2.6.1.6 Scheduling
  - 2.2.6.2 Drafting final specifications
    - 2.2.6.2.1 Referencing - titling
    - 2.2.6.2.2 Itemizing
    - 2.2.6.2.3 Describing
      - 2.2.6.2.3.1 Quantifying
      - 2.2.6.2.3.2 Qualifying

3. Implementing

- 3.1 Contracting
  - 3.1.1 Letting out bid(s)
    - 3.1.1.1 Inviting bid(s)
    - 3.1.1.2 Selecting bidder(s)
    - 3.1.1.3 Instructing bidder(s)
      - 3.1.1.3.1 Setting form of proposal
      - 3.1.1.3.2 Establishing form of contract

- 3.1.2 Preparing bid(s)
  - 3.1.2.1 Inspecting the site
  - 3.1.2.2 Quantifying labor and materials
    - 3.1.2.2.1 Describing
    - 3.1.2.2.2 Measuring
    - 3.1.2.2.3 Calculating
  - 3.1.2.3 Estimating
    - 3.1.2.3.1 Pricing
    - 3.1.2.3.2 Determining availability of resources
    - 3.1.2.3.3 Evaluating alternatives
    - 3.1.2.3.4 Consulting
    - 3.1.2.3.5 Reporting errors and omissions
    - 3.1.2.3.6 Scheduling
  - 3.1.2.4 Submitting sealed bid(s)
    - 3.1.2.4.1 Reporting proposal forms
    - 3.1.2.4.2 Posting bid bonds
- 3.1.3 Accepting Bid(s)
  - 3.1.3.1 Opening the bids
    - 3.1.3.1.1 Meeting with bidders
    - 3.1.3.1.2 Offering opportunity to withdraw bid
  - 3.1.3.2 Selecting a bid
    - 3.1.3.2.1 Examining bids
      - 3.1.3.2.1.1 Checking for accuracy
      - 3.1.3.2.1.2 Quantifying content
    - 3.1.3.2.2 Appraising bids
      - 3.1.3.2.2.1 Comparing bids
      - 3.1.3.2.2.2 Contrasting bids
    - 3.1.3.2.3 Evaluating bids
      - 3.1.3.2.3.1 Weighting bids and bidders
      - 3.1.3.2.3.2 Deciding
    - 3.1.3.2.4 Notifying contractor

- 3.2 Construction Programming
  - 3.2.1 Scheduling
    - 3.2.1.1 Grouping
      - 3.2.1.1.1 Analyzing
      - 3.2.1.1.2 Categorizing
    - 3.2.1.2 Allocating time
  - 3.2.2 Routing
    - 3.2.2.1 Establishing departure and arrival times
      - 3.2.2.1.1 Analyzing progress of project
      - 3.2.2.1.2 Notifying parties concerned
    - 3.2.2.2 Establishing path to be followed
      - 3.2.2.2.1 Estimating time relationships
      - 3.2.2.2.2 Selecting critical path

- 3.3 Procuring
  - 3.3.1 Subcontracting
    - 3.3.1.1 Letting bid(s)
      - 3.3.1.1.1 Inviting bid(s)
      - 3.3.1.1.2 Selecting bidder(s)
      - 3.3.1.1.3 Instructing bidder(s)
    - 3.3.1.2 Preparing bid(s)
      - 3.3.1.2.1 Inspecting site
      - 3.3.1.2.2 Quantifying labor and materials
      - 3.3.1.2.3 Estimating
    - 3.3.1.3 Accepting a bid
      - 3.3.1.3.1 Opening bids
      - 3.3.1.3.2 Selecting a bid
  - 3.3.2 Employing
    - 3.3.2.1 Specifying work roles
    - 3.3.2.2 Notifying prospective employees
    - 3.3.2.3 Selecting personnel
  - 3.3.3 Purchasing
    - 3.3.3.1 writing detailed specifications
    - 3.3.3.2 Ordering
    - 3.3.3.3 Checking
    - 3.3.3.4 Claiming
  - 3.3.4 Leasing
    - 3.3.4.1 Writing detailed specifications
    - 3.3.4.2 Ordering
    - 3.3.4.3 Checking
    - 3.3.4.4 Claiming
    - 3.3.4.5 Returning
  - 3.3.5 Abtaining licenses, permits and authorizations
    - 3.3.5.1 Applying
    - 3.3.5.2 Securing
- 3.4 Supervising Construction
  - 3.4.1 Directing
    - 3.4.1.1 Coordinating
    - 3.4.1.2 Assigning
    - 3.4.1.3 Administrating
    - 3.4.1.4 Inspecting
      - 3.4.1.4.1 Checking
      - 3.4.1.4.2 Verifying
  - 3.4.2 Authorizing
    - 3.4.2.1 Verifying
    - 3.4.2.2 Certifying
    - 3.4.2.3 Approving
    - 3.4.2.4 Disproving
    - 3.4.2.5 Redefining

B. Construction Production Technology

At the highest levels of generality there are no differences between production technology in manufacturing and in construction. Regardless of whether in plant or on site, materials only can be changed by separating, combining, or forming them in pre-processing, processing, and post-processing. However, marked differences occur when combinations of generic classes of processes are applied to the specific production problems of manufacture or construction. Thus, it is necessary to view the structure proposed for construction production technology and the subsequent structure of manufacturing production technology as being specific combinations and adaptations, and often unique combinations and adaptations, of the more generalized elements of industrial production technology.

Bulldozing provides an example of how separating, combining, and forming all may be part of a selected production process. Topsoil and subsoil may be separated, these elements may be combined by mixing, and they may be formed by compacting, all by bulldozing. The operating engineer and other construction personnel conceive of the process as bulldozing rather than as separating, combining, and/or forming, though relationships do exist between the knowledge of bulldozing and the knowledge of the more generalized structural elements.

Another example may further illustrate the relationships between structural elements. The generalized knowledge of explosive technology applies equally to the explosive forming of rivets in manufacturing and to the removal of stumps in construction, the differences in working knowledge must be obvious. The working knowledge of how to scrape a lathe bed and a ten-acre plot of ground possess more distinct elements than common ones. Similar distinctions and relationships occur throughout the structure of production technology and the two substructures listed under construction and manufacturing.

In their application to construction, the general classes "pre-processing" and "processing" have greater relevance to the field when they are termed "preparing the site" and "building the structure." Post-processing continues as a meaningful classification for the production technology of all that is done after the constructed work is completed. In "building the structure," the final subclass at the next level of specificity is "completing the site." This subclass could be defended as post-processing, if anything beyond completion of the actual structure were so classed. Because the site and structure are parts of the whole, the completion of the site is included in building the structure, though much of the finishing of site and structure are repeated throughout the life of the product, as in the case of repainting, rewaxing, and replanting, all of which then would be classed as post-processing. This only further confirms the earlier conclusion that the knowledge of post-processing is largely the knowledge used in initial production, used at a later time or by another individual than the original producer.

1. Preparing the Site

- 1.1 Clearing the Site
  - 1.1.1 Providing temporary access and protection
    - 1.1.1.1 Protecting personnel and property
      - 1.1.1.1.1 Posting
      - 1.1.1.1.2 Fencing
      - 1.1.1.1.3 Banking
      - 1.1.1.1.4 Ditching
      - 1.1.1.1.5 Bracing and shoring
      - 1.1.1.1.6 Weather proofing
    - 1.1.1.2 Laying roads and walkways
      - 1.1.1.2.1 Grading
      - 1.1.1.2.2 Bridging
      - 1.1.1.2.3 Compacting
      - 1.1.1.2.4 Surfacing
      - 1.1.1.2.5 Rolling
  - 1.1.2 Reducing obstacles
    - 1.1.2.1 Demolishing and salvaging
      - 1.1.2.1.1 Disassembling
      - 1.1.2.1.2 Wrecking
      - 1.1.2.1.3 Bulldozing
      - 1.1.2.1.4 Cutting
      - 1.1.2.1.5 Chaining
      - 1.1.2.1.6 Blasting
      - 1.1.2.1.7 Burning
    - 1.1.2.2 Extracting
      - 1.1.2.2.1 Draining
      - 1.1.2.2.2 Rerouting
      - 1.1.2.2.3 Digging
      - 1.1.2.2.4 Ripping
      - 1.1.2.2.5 Scraping
      - 1.1.2.2.6 Grubbing
  - 1.1.3 Handling Materials
    - 1.1.3.1 Transferring materials
      - 1.1.3.1.1 Loading and hauling
      - 1.1.3.1.2 Dragging
      - 1.1.3.1.3 Pushing
      - 1.1.3.1.4 Pumping
    - 1.1.3.2 Disposing of materials on-site
      - 1.1.3.2.1 Stockpiling - stacking
      - 1.1.3.2.2 Burying
      - 1.1.3.2.3 Burning
      - 1.1.3.2.4 Spreading

- 1.2 Setting up Temporary Facilities
  - 1.2.1 Establishing temporary shelters
    - 1.2.1.1 Transporting temporary shelters
      - 1.2.1.1.1 Hauling
      - 1.2.1.1.2 Towing
    - 1.2.1.2 Setting-up temporary shelters
      - 1.2.1.2.1 Parking
      - 1.2.1.2.2 Fabricating
  - 1.2.2 Providing temporary utilities
    - 1.2.2.1 Providing water
      - 1.2.2.1.1 Connecting
      - 1.2.2.1.2 Plumbing
      - 1.2.2.1.3 Welling
      - 1.2.2.1.4 Storing
    - 1.2.2.2 Providing power
      - 1.2.2.2.1 Connecting
      - 1.2.2.2.2 Wiring
      - 1.2.2.2.3 Generating

- 1.3 Surveying for Construction
  - 1.3.1 Referencing to existing features
    - 1.3.1.1 Measuring
      - 1.3.1.1.1 Reading
      - 1.3.1.1.2 Recording
    - 1.3.1.2 Marking
  - 1.3.2 Laying out the structure
    - 1.3.2.1 Establishing control points
      - 1.3.2.1.1 Measuring
      - 1.3.2.1.2 Marking
    - 1.3.2.2. Establishing offset lines
      - 1.3.2.2.1 Measuring
      - 1.3.2.2.2 Marking
      - 1.3.2.2.3 Leveling
      - 1.3.2.2.4 Protecting

- 1.4 Earthworking
  - 1.4.1 Mobilizing equipment
    - 1.4.1.1 Transporting
      - 1.4.1.1.1 Driving
      - 1.4.1.1.2 Hauling and towing
    - 1.4.1.2 Setting up
      - 1.4.1.2.1 Unloading
      - 1.4.1.2.2 Positioning
      - 1.4.1.2.3 Assembling
      - 1.4.1.2.4 Servicing

- 1.4.2 Earthmoving
  - 1.4.2.1 Loosening
    - 1.4.2.1.1 Blasting
    - 1.4.2.1.2 Breaking and spalling
    - 1.4.2.1.3 Scarifying and ripping
  - 1.4.2.2 Extracting
    - 1.4.2.2.1 Digging
    - 1.4.2.2.2 Scraping
    - 1.4.2.2.3 De-watering
  - 1.4.2.3 Transferring
    - 1.4.2.3.1 Loading and hauling
    - 1.4.2.3.2 Pushing
    - 1.4.2.3.3 Pumping
    - 1.4.2.3.4 Conveying
  - 1.4.2.4 Disposing
    - 1.4.2.4.1 Stockpiling - stacking
    - 1.4.2.4.2 Depositing
    - 1.4.2.4.3 Spreading
- 1.4.3 Protecting existing utilities and structures
  - 1.4.3.1 Rerouting
  - 1.4.3.2 Bracing and shoring
  - 1.4.3.3 Underpinning
    - 1.4.3.3.1 Digging
    - 1.4.3.3.2 Supporting
- 1.4.4 Shaping and stabilizing earthworks
  - 1.4.4.1 Cleaning or washing
  - 1.4.4.2 Grading
    - 1.4.4.2.1 Compacting
    - 1.4.4.2.2 Grouting
    - 1.4.4.2.3 Scaling
    - 1.4.4.2.4 Filling
  - 1.4.4.3 Sloping
  - 1.4.4.4 Sheathing
  - 1.4.4.5 Bracing and shoring
  - 1.4.4.6 Treating
  - 1.4.4.7 Piling
  - 1.4.4.8 Cofferdamming

2. Building the Structure

- 2.1 Setting Foundations
  - 2.1.1 Making and placing forms
    - 2.1.1.1 Building forms
      - 2.1.1.1.1 Laying out
      - 2.1.1.1.2 Cutting
      - 2.1.1.1.3 Preassembling components

- 2.1.1.2 Assembling in place
  - 2.1.1.2.1 Transferring
  - 2.1.1.2.2 Positioning
  - 2.1.1.2.3 Fastening
  - 2.1.1.2.4 Stabilizing and adjusting
- 2.1.1.3 Treating forms
  - 2.1.1.3.1 Cleaning
  - 2.1.1.3.2 Coating
  - 2.1.1.3.3 Soaking

- 2.1.2 Setting reinforcement
  - 2.1.2.1 Cleaning and shaping
  - 2.1.2.2 Transferring and placing
  - 2.1.2.3 Supporting
    - 2.1.2.3.1 Seating
    - 2.1.2.3.2 Tying
- 2.1.3 Preparing foundation materials
  - 2.1.3.1 Treating
    - 2.1.3.1.1 Washing
    - 2.1.3.1.2 Chilling
  - 2.1.3.2 Proportioning and batching
    - 2.1.3.2.1 Screening
    - 2.1.3.2.2 Measuring
  - 2.1.3.3 Mixing
- 2.1.4 Handling materials
  - 2.1.4.1 Transferring
    - 2.1.4.1.1 Hauling
    - 2.1.4.1.2 Conveying
    - 2.1.4.1.3 Pumping
  - 2.1.4.2 Placing
    - 2.1.4.2.1 Dumping
    - 2.1.4.2.2 Chuting
  - 2.1.4.3 Consolidating
    - 2.1.4.3.1 Vibrating
    - 2.1.4.3.2 Tamping and spading
  - 2.1.4.4 Building in inserts, anchors, ties and hangers
  - 2.1.4.5 Finishing
    - 2.1.4.5.1 Striking off
    - 2.1.4.5.2 Edging
    - 2.1.4.5.3 Floating
- 2.1.5 Bonding
  - 2.1.5.1 Preparing surfaces
    - 2.1.5.1.1 Scraping
    - 2.1.5.1.2 Washing
    - 2.1.5.1.3 Grouting
  - 2.1.5.2 Jointing
    - 2.1.5.2.1 Placing
    - 2.1.5.2.2 Tamping

- 2.1.6 Curing
    - 2.1.6.1 Controlling moisture
        - 2.1.6.1.1 Ponding and flooding
        - 2.1.6.1.2 Mist spraying
        - 2.1.6.1.3 Covering
        - 2.1.6.1.4 Chemical treating
    - 2.1.6.2 Controlling temperature
        - 2.1.6.2.1 Chilling
        - 2.1.6.2.2 Covering
- 2.1.7 Removing forms
    - 2.1.7.1 Stripping forms
        - 2.1.7.1.1 Unfastening
        - 2.1.7.1.2 Tapping
        - 2.1.7.1.3 Pulling
        - 2.1.7.1.4 Lifting and stacking
    - 2.1.7.2 Cleaning forms
        - 2.1.7.2.1 Chipping and scraping
        - 2.1.7.2.2 Washing
    - 2.1.7.3 Stockpiling
- 2.1.8 Finishing foundations
    - 2.1.8.1 Cleaning
        - 2.1.8.1.1 Patching
        - 2.1.8.1.2 Chipping and chiseling
        - 2.1.8.1.3 Treating
    - 2.1.8.2 Backfilling
        - 2.1.8.2.1 Bulldozing
        - 2.1.8.2.2 Compacting

2.2 Building the Major Structural Elements

- 2.2.1 Preparing materials
    - 2.2.1.1 Laying out
    - 2.2.1.2 Cutting
    - 2.2.1.3 Forming
    - 2.2.1.4 Proportioning and mixing
    - 2.2.1.5 Treating
- 2.2.2 Fabricating components and temporary forms
    - 2.2.2.1 Preparing materials
    - 2.2.2.2 Sub-assembling
- 2.2.3 Setting reinforcement
- 2.2.4 Handling materials and components
    - 2.2.4.1 Transferring
        - 2.2.4.1.1 Hoisting
        - 2.2.4.1.2 Carrying
    - 2.2.4.2 Positioning
        - 2.2.4.2.1 Locating
        - 2.2.4.2.2 Bracing and holding
        - 2.2.4.2.3 Aligning
        - 2.2.4.2.4 Placing

    - 2.2.4.3 Assembling
      - 2.2.4.3.1 Fastening
        - 2.2.4.3.1.1 Pinning
        - 2.2.4.3.1.2 Welding
      - 2.2.4.3.2 Bonding
        - 2.2.4.3.2.1 Joining
        - 2.2.4.3.2.2 Adhering
  - 2.2.5 Treating
    - 2.2.5.1 Curing
    - 2.2.5.2 Tensioning
    - 2.2.5.3 Pressurizing
    - 2.2.5.4 Coating
    - 2.2.5.5 Fireproofing
  - 2.2.6 Removing temporary forms
    - 2.2.6.1 Stripping
    - 2.2.6.2 Cleaning
    - 2.2.6.3 Stockpiling
  - 2.2.7 Finishing

- 2.3 Installing Circulatory Systems
  - 2.3.1 Installing permanent utilities and mechanical plant
    - 2.3.1.1 Preparing materials and components
      - 2.3.1.1.1 Laying out
      - 2.3.1.1.2 Cutting
      - 2.3.1.1.3 Forming
      - 2.3.1.1.4 Treating
      - 2.3.1.1.5 Fabricating components
    - 2.3.1.2 Handling materials
      - 2.3.1.2.1 Transferring
      - 2.3.1.2.2 Positioning
    - 2.3.1.3 Fastening in place
      - 2.3.1.3.1 Pinning
      - 2.3.1.3.2 Welding
      - 2.3.1.3.3 Hooking
      - 2.3.1.3.4 Clamping
      - 2.3.1.3.5 Embedding and seating
    - 2.3.1.4 Connecting and jointing
      - 2.3.1.4.1 Bonding
      - 2.3.1.4.2 Pinning
      - 2.3.1.4.3 Welding
      - 2.3.1.4.4 Soldering
      - 2.3.1.4.5 Splicing
      - 2.3.1.4.6 Clamping
      - 2.3.1.4.7 Socketing
      - 2.3.1.4.8 Sealing
      - 2.3.1.4.9 Treating

  - 2.3.2 Providing temporary equipment
    - 2.3.2.1 Handling equipment
      - 2.3.2.1.1 Transferring
      - 2.3.2.1.2 Positioning
      - 2.3.2.1.3 Assembling
    - 2.3.2.2 Securing in place
      - 2.3.2.2.1 Pinning
      - 2.3.2.2.2 Welding
      - 2.3.2.2.3 Clamping
      - 2.3.2.2.4 Tying
      - 2.3.2.2.5 Bracing
      - 2.3.2.2.6 Hooking
    - 2.3.2.3 Removing temporary equipment
      - 2.3.2.3.1 Disassembling
      - 2.3.2.3.2 Handling equipment
        - 2.3.2.3.2.1 Loading
        - 2.3.2.3.2.2 Hauling
        - 2.3.2.3.2.3 Stockpiling

- 2.4 Completing the Structure
  - 2.4.1 Enclosing the structure (rough finishing)
    - 2.4.1.1 Preparing materials
      - 2.4.1.1.1 Laying out
      - 2.4.1.1.2 Cutting
      - 2.4.1.1.3 Forming
      - 2.4.1.1.4 Mixing
      - 2.4.1.1.5 Making temporary formwork
      - 2.4.1.1.6 Fabricating components
      - 2.4.1.1.7 Treating
    - 2.4.1.2 Handling materials and components
      - 2.4.1.2.1 Transferring materials and componen
      - 2.4.1.2.2 Positioning materials and component
    - 2.4.1.3 Assembling in place
      - 2.4.1.3.1 Pinning
      - 2.4.1.3.2 Welding
      - 2.4.1.3.3 Bonding
      - 2.4.1.3.4 Coupling
  - 2.4.2 Finishing the structure (fine finishing)
    - 2.4.2.1 Preparing subsurfaces
      - 2.4.2.1.1 Abrading
      - 2.4.2.1.2 Grounding
    - 2.4.2.2 Preparing materials
      - 2.4.2.2.1 Laying out
      - 2.4.2.2.2 Cutting
      - 2.4.2.2.3 Forming
      - 2.4.2.2.4 Mixing
      - 2.4.2.2.5 Making temporary formwork
      - 2.4.2.2.6 Assembling prefabricated components
      - 2.4.2.2.7 Treating

- 2.4.2.3 Handling materials
  - 2.4.2.3.1 Transferring materials
  - 2.4.2.3.2 Positioning
- 2.4.2.4 Trimming
  - 2.4.2.4.1 Fastening and connecting
    - 2.4.2.4.1.1 Pinning
    - 2.4.2.4.1.2 Welding
    - 2.4.2.4.1.3 Bonding
    - 2.4.2.4.1.4 Coupling
  - 2.4.2.4.2 Coating and applying
    - 2.4.2.4.2.1 Brushing
    - 2.4.2.4.2.2 Spraying
    - 2.4.2.4.2.3 Rolling
    - 2.4.2.4.2.4 Troweling
    - 2.4.2.4.2.5 Sealing
- 2.4.2.5 Removing equipment and debris
  - 2.4.2.5.1 Demobilizing equipment
    - 2.4.2.5.1.1 Disassembling
    - 2.4.2.5.1.2 Transferring
  - 2.4.2.5.2 Cleaning up
    - 2.4.2.5.2.1 Scraping
    - 2.4.2.5.2.2 Picking up
    - 2.4.2.5.2.3 Sweeping
    - 2.4.2.5.2.4 Washing
    - 2.4.2.5.2.5 Polishing

- 2.5 Completing the Site
  - 2.5.1 Removing temporary plant and facilities
    - 2.5.1.1 Removing temporary water and power facilities
      - 2.5.1.1.1 Disassembling, disconnecting
      - 2.5.1.1.2 Handling components
    - 2.5.1.2 Removing contractor's equipment
      - 2.5.1.2.1 Disassembling
      - 2.5.1.2.2 Handling equipment
        - 2.5.1.2.1.1 Loading
        - 2.5.1.2.1.2 Hauling
  - 2.5.2 Landscaping
    - 2.5.2.1 Building accesses
      - 2.5.2.1.1 Surveying for accesses
      - 2.5.2.1.2 Earthmoving
      - 2.5.2.1.3 Setting the base
      - 2.5.2.1.4 Installing circulatory systems
      - 2.5.2.1.5 Finishing the access
        - 2.5.2.1.5.1 Surfacing
        - 2.5.2.1.5.2 Trimming

- 2.5.3 Building features
  - 2.5.3.1 Surveying for construction
  - 2.5.3.2 Earthmoving
  - 2.5.3.3 Building the feature
  - 2.5.3.4 Installing circulatory systems
  - 2.5.3.5 Finishing the feature
- 2.5.4 Shaping and finishing earth
  - 2.5.4.1 Laying out
  - 2.5.4.2 Earthmoving
    - 2.5.4.2.1 Banking
    - 2.5.4.2.2 Filling
  - 2.5.4.3 Preparing the surface
    - 2.5.4.3.1 Grading
    - 2.5.4.3.2 Turning
    - 2.5.4.3.3 Spreading
    - 2.5.4.3.4 Treating
  - 2.5.4.4 Planting and surfacing
    - 2.5.4.4.1 Seeding
    - 2.5.4.4.2 Sodding
    - 2.5.4.4.3 Digging and placing
    - 2.5.4.4.4 Spreading
    - 2.5.4.4.5 Treating
    - 2.5.4.4.6 Protecting
- 2.5.5 Removing landscaping equipment and debris
  - 2.5.5.1 Demobilizing equipment
    - 2.5.5.1.1 Loading and hauling
    - 2.5.5.1.2 Towing
    - 2.5.5.1.3 Driving
  - 2.5.5.2 Cleaning up
    - 2.5.5.2.1 Picking up
    - 2.5.5.2.2 Raking
    - 2.5.5.2.3 Sweeping
    - 2.5.5.2.4 Burying
    - 2.5.5.2.5 Burning
    - 2.5.5.2.6 Dumping

3. Post Processing

- 3.1 Repairing
- 3.2 Altering
- 3.3 Installing
- 3.4 Maintaining

C. Construction Personnel Technology

In the two preceding substructures of construction technology, the knowledge of how to do included various combinations of the more generalizeable elements of industrial technology. In personnel technology, the same elements obtain at both the industrial and at the construction levels. For example, hiring still involves only hiring. Regardless of the level of specificity of the knowledge of how to hire efficiently, it does not combine with retiring in any single act.

There are differences between manufacturing personnel technology and construction personnel technology. They are of two general kinds. Because of the on-site nature of construction, and the resultant mobility of most construction personnel, much of the knowledge of manufacturing personnel technology finds little or no application in construction. For example, much of the sophisticated knowledge of structuring the work environment within buildings (use of music, color coding, lighting, etc.) has little application to a dam site or a highway construction project. Thus, construction personnel technology is more limited in scope than manufacturing personnel technology.

Secondly, some of the knowledge of efficient personnel practices in construction is unique to this facet of industry. For example, the knowledge of how to improve personnel safety in the construction of a bridge which is anchored on a sheer cliff face finds no counterpart in manufacturing technology.

The following framework of construction personnel technology provides a consistent general framework from which to view the planned, organized, and controlled personnel practices which affect the behavior of all construction personnel. As indicated earlier, this knowledge is used throughout the managed production system, but for purposes of identification and analysis, it is efficient to place it within an independent structure.

1. Hiring

    1.1 Recruiting
        1.1.1 Disseminating vacancy notices
        1.1.2 Contacting employment agencies
        1.1.3 Making personal contacts
        1.1.4 Reimbursing interview costs
        1.1.5 Communicating advantages

    1.2 Selecting
        1.2.1 Testing
        1.2.2 Interviewing
        1.2.3 Obtaining and checking references
        1.2.4 Matching qualifications with work requirements
        1.2.5 Reporting results to applicants and management

    1.3 Inducting
        1.3.1 Appointing
        1.3.2 Reimbursing moving costs
        1.3.3 Establishing personnel record
        1.3.4 Distributing records to appropriate departments
        1.3.5 Orienting to work
        1.3.6 Answering employee questions

2. Training

    2.1 On the job training
        2.1.1 Apprenticing
        2.1.2 Interning
        2.1.3 Coaching

2.2 Other training
2.2.1 Conducting conferences and workshops
2.2.2 Providing instructional materials
2.2.3 Classroom instructing
2.2.4 Sending to outside programs

3. Working

3.1 Providing economic rewards
3.1.1 Paying wages and salaries
3.1.2 Providing fringe benefits

3.2 Providing physical setting
3.2.1 Housekeeping
3.2.2 Lighting
3.2.3 Heating, cooling, and ventilating
3.2.4 Controlling sound, vibration, and rhythm
3.2.5 Coloring
3.2.6 Posturing
3.2.7 Protecting
3.2.8 Meeting personal needs

3.3 Providing social environment
3.3.1 Providing recreational activities
3.3.2 Providing social programs
3.3.3 Providing communication channels
3.3.4 Structuring the work group
3.3.5 Acting on surveys
3.3.6 Disciplining
3.3.7 Merit rating
3.3.8 Giving service awards

4. Advancing

4.1 Promoting
4.1.1 Reassigning upward
4.1.2 Reclassifying upward

4.2 Demoting
4.2.1 Reassigning downward
4.2.2 Reclassifying downward

4.3 Discharging
4.3.1 Separating
4.3.2 Relocating
4.3.3 Laying off

5. Retiring

- 5.1 Counseling
  - 5.1.1 Making pre-retirement plans
  - 5.1.2 Serving after retirement

- 5.2 Pre-retirement job engineering
  - 5.2.1 Reducing work load
  - 5.2.2 Increasing leisure time
  - 5.2.3 Changing worker function

- 5.3 Recognizing service
  - 5.3.1 Disseminating announcements
  - 5.3.2 Awarding mementos
  - 5.3.3 Holding recognition meetings
  - 5.3.4 Posting names of retirees

- 5.4 Awarding retirement benefits
  - 5.4.1 Making payments
  - 5.4.2 Providing fringe benefits

D. Constructed Material Goods

A number of systems have been designed for classifying the industrial material goods which are the products of construction. While these systems apparently serve their individual purposes, they are not internally consistent and thus do not provide an adequate classification system for educational purposes. A review of these systems reveals that construction products may be classified according to (1) ownership, (2) location, (3) function, (4) form, and (5) process. However, the most common approach to developing a classification system for construction products has been to combine some of these differentiating characteristics. For example, the United States Department of Commerce uses ownership and function as the bases for their classification system.

The primary problem in using any of these differentiating characteristics or combinations of them is the lack of mutual exclusiveness within the sub-orders. For example, public and private ownership has little to do with the construction practices employed in the construction of a building. Contractors may even construct buildings for future sale without knowing whether they will be ultimately owned by an individual, a corporation, or by government. Similarly, a product may have common characteristics whether constructed on land or in the water. Furthermore, to know that a highway and a home are both built on land distinguishes little between the two. By the same token, it provides little basis for grouping them.

Many constructed products serve multiple functions, as is the case when residences, stores, and even small factories occupy a single building. In the same way, some non-buildings, such as dams or steel towers, may have buildings integral within their structure.

Mass and reinforced categories also fail to lend meaning to man's constructed works. Some of the most massive are of reinforced construction. Some of the typical mass structures, dams, are to some extent reinforced.

At least one further difficulty plagues those who attempt to classify the products of construction. While there are certainly differences in types of manufactured products, the class differences are perhaps less extensive than those in comparable product classes in construction (though admittedly even the identification of adequate classes poses a difficult, if not insurmountable, problem). Even entire classes of constructed works may consist largely of individualized or custom products, whereas in manufacturing, hundreds of thousands of automobiles may be stamped from dies which are intended to be identical. Thus, while manufactured products are largely mass-produced, constructed works are not. Also, manufactured products often perform a single function and constructed works do not. These differences are reflected in the complexity of the problems encountered in classifying the two types of industrial material goods.

In view of the above-described classification difficulties, perhaps the best present solution for educational purposes would be to subject any selected constructed work to analysis by all of the listed characteristics. For example, a television tower could be publicly or privately owned, located on land or water (perhaps in the future in space), serving an educational or economic function, be of mass or reinforced construction, and be either a building or a non-building or a combination building and non-building (in the event there is a building within the tower).

Thus, no adequate classification system is presented for man's constructed works, because their largely custom and often multi-function nature defies classification. Instead, it is proposed that the following characteristics of constructed works be employed to lend intelligibility to any selected product from the vast array of those which exist around the world.

Characteristics of constructed works:

1. Ownership
   - 1.1 Private
     - 1.1.1 Individual
     - 1.1.2 Group
   - 1.2 Public
     - 1.2.1 Local
     - 1.2.2 State
     - 1.2.3 National
     - 1.2.4 International
2. Location
   - 2.1 Air
   - 2.2 Land
   - 2.3 Water
   - 2.4 Space
   - 2.5 Underground
3. Function
   - 3.1 Family
   - 3.2 Education
   - 3.3 Religion
   - 3.4 Government
   - 3.5 Economic
4. Process
   - 4.1 Mass
   - 4.2 Reinforced
5. Form
   - 5.1 Building
   - 5.2 Non-building

VI. Manufacturing Technology

The detailing of a structure of manufacturing technology is a future task for this Project. According to the Project schedule, the first year of a two-year instructional program, a study of construction technology, would be developed initially. Because of this, construction technology was structured to provide an organized source of this subject matter. In subsequent phases of the Project, when it becomes necessary to develop the second-year program in manufacturing technology, the detailed structure of this knowledge will be developed.

CONCLUDING STATEMENT

The generalized structure of industrial technology presented in Chapter III is tentative and must be further refined. The more detailed structure presented in this Chapter is perforce more tentative and in need of extensive refinement. Despite this, the present structure serves as an adequate initial guide in the development of an instructional program in construction technology, the immediate goal of this Project. Also, there is no ultimate development of this dynamic body of knowledge, particularly at the finite level.

Chapter V

The Selection and Organization of Learning Experiences and the Development of Course Materials from a Structured Body of Knowledge

Previous chapters have been directed toward the question of the knowledge source for industrial arts. This knowledge source has never been defined adequately. The task was undertaken to identify and codify a body of knowledge which the staff of the Industrial Arts Curriculum Project has termed the discipline of industrial technology. The purpose of this effort was to improve the substantive base for instruction in industrial arts. It should be restated that this development must not be construed as the ultimate structure of the body of knowledge from which industrial arts subject matter is selected. The structure presented in the previous chapter is therefore perforce tentative. Further work will need to be done and it is possible that the field will be wholly redefined as a consequence of this further work.

This chapter will be directed toward an examination of the conditions, elements, or factors which must be considered before learning experiences are selected and organized and course materials are developed from the structured body of knowledge of industrial technology. Teaching programs could be developed for all levels of the educational ladder, from elementary through college and adult curricula, from the knowledge source of industrial technology. The immediate concern of the Industrial Arts Curriculum Project is to develop a two-year articulated program for the junior high school years.

A conscious attempt must be made to base curricular decisions upon a sound rationale. The considerations within this chapter represent that attempt.

Contemporary curriculum improvement projects appear to follow a somewhat common developmental pattern of 1) identifying and structuring the body of knowledge that will serve as the source of course content, 2) stating general objectives, 3) writing textbooks, 4) developing a series of exciting learning experiences, 5) building measuring devices to determine if appropriate learnings were mastered, and 6) training the teachers. There are, of course, exceptions to this pattern. It is very difficult for someone who is trying to examine a particular project or who is trying to develop a new project to determine what guidelines were used or what factors were considered in making decisions at various stages of program development. These guidelines or factors need to be made explicit in order to determine if logical and pedagogically sound processes were followed. In addition, such guidelines would help other curriculum developers learn from the successes and failures of prior work.

Halverson cited the need for a discussion of rationale when he stated that "the great need at all times is conscious, deliberate decision making, based on clearly defined criteria. These criteria stem from our values and value patterns, our educational goals, and the nature of the learner. The educator is in a strategic position to bring together all of these considerations for curriculum decision making" (Halverson, 1961, p.14).

This is a difficult task, and it is easy to see why many curriculum projects have not engaged in such deliberations; since in many cases, those in charge of projects are specialists in fields other than that of the educationist, and not only do they not know how to define these criteria, but they are not even aware of the need for them. This apparent lack of concern on the part of some of the curriculum improvement projects partially explains why professional educators, especially in the area of curriculum development, look with disfavor on many of the new curricula. Some of the negative reactions may be attributed to defensive behavior, but quite a bit of it reflects a genuine concern that education not regress to the state that it was in prior to what might be called the "Progressive Era." Hilgard reflects that concern when he states that:

> The emphasis on the intellectual in education is fine, but it can easily produce, in new form, the old misunderstandings that gave rise to the exaggerated theories of formal discipline. The subject-matter specialist is likely to think that his material is fundamentally so interesting that as long as it is arranged logically, and is comprehensible, the psychological problems will take care of themselves (Hilgard, 1964, pp. 412-413).

Ralph W. Tyler raises four questions (four divisions of curriculum inquiry) which reflect the concern for a conscious attempt to make curricular decisions based upon a sound rationale:

1. What educational purposes should the school seek to attain?

2. What educational experiences can be provided that are likely to attain these purposes?
3. How can these educational experiences be effectively organized?
4. How can we determine whether these purposes are being attained? (Tyler, 1966, p. 25)

He indicates that the evolving conceptions of knowledge and of the learner are central in consideration of these questions.

Glaser recommends a four step instructional design procedure involving 1) analysis of the subject matter domain, 2) study of the characteristics of the learner, 3) construction of teaching procedures and materials, 4) evaluation of learner performance against established criteria. He states:

> If the instructional designer, working in a research and development setting, did exist, then it can be assumed that he would operate in the following manner: First, he would analyze the subject-matter domain under consideration—reading, mathematics, or other. He would think of a domain in terms of the performance competencies which comprise it. He would analyze representative instances of subject-matter competence according to the stimulus characteristics of the content involved and the properties of the responses the student makes to the content. (Response is used here to mean broad activity ranging from memorizing to problem-solving). He would further analyze the structural characteristics of the domain, perhaps according to its conceptual hierarchies and operating rules. Second, this instructional designer would turn his attention to the characteristics of the students that are to be taught. He would determine the extent to which the students already have acquired some of the things to be learned, the extent to which they have certain content prerequisites, the

> extent to which their antecedent learnings might facilitate or interfere with the new learning, and the extent to which the students have certain aptitude-like prerequisites consisting of necessary sensory discriminations and motor skills.
>
> These first two steps provide information to the educational designer about the target performance to be obtained and the existing preinstructional behavior of the learner. The designer must then proceed to get from one state to the other. This sets up his third task. This task consists of helping the student go from the preinstructional behavioral state to a state of subject-matter competence. This requires the construction of teaching procedures and materials to be employed in the educational process. As part of this process, he must take account of motivational effects and the ability of humans to generalize and extrapolate; this is accomplished by providing conditions which will result in the maintenance and extension of the competence being taught. Finally, the educational designer must make provision for assessing and evaluating the nature of the competence and kind of knowledge achieved by the learner in relation to some performance criteria that have been established (Glaser, 1966, pp. 216-217).

The staff of the Industrial Arts Curriculum Project has attempted to answer the question: "What are the factors or elements which should guide the selection and organization of learning activities and the development of course materials in industrial arts?" The following six general factors or elements are appropriate, necessary, and sufficient for consideration when one makes a serious and rational attempt to select learning activities and develop course materials: 1) The Structure of the Body of Knowledge, 2) Desired Behavioral Change or Objectives of Instruction, 3) The Nature of the Learner, 4) School Facilities and Materials, 5) Instructional Procedures and Materials, and 6) Measurement and Evaluation. Each will be considered in turn.

STRUCTURE OF THE BODY OF KNOWLEDGE

In curriculum development a major issue is: should the curriculum be problem-centered, or should the curriculum be subject-centered, or--as some put it--should the emphasis be on process, or should it be on content? By definition, an issue often involves diametrically opposed views, and it seems that many educators who are concerned with various aspects of curriculum development prefer it this way. Relatively few real attempts have been made to find the appropriate mix of content and process or to construct programs that combine the subject-centered and the whole-child approach.

For the past thirty years, professional educationists have generally held very tightly to the problem-centered curriculum with an emphasis on the whole-child, as opposed to an approach that places almost exclusive emphasis on acquisition of knowledge. On the other hand, a vast majority of classroom teachers have not accepted the problem-centered curriculum. Rather teachers have placed major emphasis on mastery of content through an assign, recite, and test approach, without giving enough attention to the organization of content and to meaningful understanding in the minds of children. Each group has failed to demonstrate that their way was better than others and, in a sense, were forced to relinquish their control over various aspects of the curriculum. One might question whether they were forced to relinquish control, or whether their lack of measurable success left a vacuum that invited outside influences to take control.

In any case, the past fifteen years have seen a decided shift toward an approach that emphasizes subject matter--not, however, subject matter as it is traditionally known--but the emphasis now is on the structure of knowledge. The knowledge explosion has forced a placing of priority on structure that enhances transfer to replace facts that are learned within an inadequate context.

The Industrial Arts Curriculum Project is committed to the belief that a structured body of knowledge unique to industry does exist, and this body of knowledge has been termed industrial technology by the Project. The Project staff has taken the position that this body of knowledge should serve as the major source of content for industrial arts; and it will, therefore, greatly influence the selection of objectives, learning experiences, and course materials.

One reaction to this statement may be that the Industrial Arts Curriculum Project is returning to the subject-centered approach. This is not the case.

Foshay has made a clear distinction between the subject-centered, the problem-centered, and the discipline-centered approaches. He sees the subject-centered approach as being characterized by 1) an attempt at analysis of certain intellectual fields translated to "school subjects" with the acquisition of knowledge of these "subjects" as an end, and 2) an assumption that it is the schools' function to fit the child to the subject-matter. The problem-centered approach finds content arising out of the lives of the student and the contemporary scene as well as from printed materials. The third approach, the discipline-centered approach, seems to offer opportunity to overcome several shortcomings of the other two: the lack of contemporary concern for the child where he is right now, as found in the subject-centered approach, and the lack of search for fundamental truths which, in many cases, characterize problem-centered approaches. The major feature of the discipline-centered approach may be described as the teaching and learning of a process of inquiry through a school program that focuses on leading students to discover the principal concepts of a discipline, and the interrelationship of concepts. In the process of examining the domain of the discipline, the student learns to use the methods or tools used by those in the discipline, and to apply these methods when confronting new aspects of the discipline--thus becoming an "active learner" (Foshay, 1962, pp. 66-71).

According to Foshay then, two important factors arising from the structure of the body of knowledge that influence the selection of learning experience should be: concern with major concepts, and a focus on the methods of acquisition of these concepts.

Bruner stated four general claims that he believes can be made if these factors are taken into account:

1. A subject becomes more comprehensible if fundamental principles are stressed,
2. Facts are easily forgotten, but principles remain and provide the vehicle needed to reconstruct details,

3. Adequate transfer of training appears to have understanding of fundamental principles as a prerequisite, and

4. The knowledge lag or gap in a field is reduced when principles in the field are examined and re-examined, since principles stand the test of time better than do facts (Bruner, 1963, pp. 23-26).

As was noted in the introduction, a major concern of many professional educationists is that schools not return to subject-centered approaches to curriculum. They are concerned with the focus of curricular programs based on a structured body of knowledge. In many cases, it would take very little for the scales to be tipped in such a way that the learning of structure or principles is forgotten, and the acquisition of facts takes over. The balance and the interaction between facts and principles must be stressed. Goodlad illustrates this factor when he states that one test of a curricular scheme lies in the relationship between the topic, problem, or question being used to involve the student, and the central concepts and methods that the student is to learn. If you have too much emphasis on the first, the focus is on facts; if you have too much of the second, there is too much focus on the methods of those in the discipline (Goodlad, 1964, p. 58).

The structure of the body of knowledge also contributes another dimension that must be considered when selecting learning activities. This dimension is very closely related to focus, which was mentioned above. It has to do with scope and refers to the treatment of the relationships between the field or discipline being studied and other fields or disciplines. In the case of industrial arts, it is a question of what one considers to be that which is uniquely industrial arts, and how that which is uniquely industrial arts (or the discipline, if you will, of industrial technology) is related to other disciplines.

The way in which this factor or element should or does affect selection of learning activities can be seen if one looks at the limits or the boundaries of the discipline, as defined. A discipline, first of all, is a "way of knowing" which represents a portion of a domain of knowledge; and that domain may involve form, events or phenomena, values, or efficient action (see pages 8-10 of Chapter I). Another discipline or several disciplines might deal with this same domain directly or indirectly. The boundaries or limits on the definition of the discipline are determined by examining the way in which those in the discipline deal with those things in the domain (Foshay, 1962, p. 69).

Scope, as a dimension or element, becomes very important. Is the emphasis of instruction going to be placed on the way in which the discipline or field, in this case industrial technology, treats the data of industry? Or, is the emphasis going to be placed on how all disciplines or fields concerned with industry treat the same data? If one takes the former approach, he comes very close to placing himself in a position where his course of study can be labeled as subject-centered. If he takes the latter approach, he can be accused of teaching something other than the structure of the body of knowledge of his discipline.

In the case of industrial arts, the element of scope is very crucial, and has--or should have--real influence on selection of learning activities and the development of materials. The position is taken that emphasis should be on the way industrial technologists treat the data of industry, as opposed, for example, to how the advertising technologists treat them.

On the other hand, there are other disciplines that focus on the same domain, or overlap with the domain, that is the concern of industrial technology. For instance, economics, chemistry, and marketing are a few of the fields that treat some of the same data; yet they treat them in different ways. In building a program of industrial arts, the major emphasis should be on that which is unique to industry; yet there must be some concern with how other fields treat the same data. It would be very easy to end up with a program that was all industrial arts (series of experiences drawn only from the body of knowledge of industrial technology) and nothing else, or to end up with a program that is a lot of things, one of which is industrial arts. Both of these are to be avoided. In industrial arts, both of these unacceptable positions would be exemplified by, on one hand, a course that was similar to manual training but on a much larger scale, and on the other hand, a multi-faceted industrial arts that comes very close to being a course in science or the social studies.

There are several factors that must be considered when decisions are made that concern where emphasis should be placed. Yet, there is a direct relationship between where one puts emphasis and the learning experiences that are planned. Broudy makes this point when he expresses the following concerns about new curriculum proposals:

> 1. Are objectives focusing on factors that are unique to the material or content being studied, or are they also concerned with side effects and long-range factors?
>
> 2. Is the focus on simply getting children excited about a particular subject, or is it on how this particular subject helps to meet certain social, cultural, and personal requirements?
>
> 3. Is the emphasis mainly on knowledge within the particular discipline, or is there a concern for an establishment of relationships with other areas of knowledge?
>
> 4. Is it to be assumed that activities successful for teaching the structure of one discipline should be duplicated in teaching the structure of any other, or should there be a systematic consideration of the way in which each structure is taught? (Adapted from Broudy, 1966, pp. 21-22).

He, of course, prefers the latter choice in each of his statements.

The NEA Project on Instruction has stated its position on this particular factor in this way:

> Recommendation: The content of the curriculum should be organized in such ways that students may progress, from early to later school years, toward an increasingly mature utilization and organization of their knowledge. Helping learners see interrelationships and achieve unity from the diversity of knowledge is basic to any organization of content. (NEA, 1963, p. 43).
>
> This recommendation is based on the belief that:
>
> Interrelationships among the data from the various subject fields must be recognized. The information thus assembled must be so

5

> organized and applied that it illuminates the problem and reveals courses of action for dealing with it (NEA, 1963, p. 42).

The key point seems to be that interrelationships are studied by using data from allied fields to illuminate the problem in the major field being studied:

This then would indicate that:

> If . . .the learner has experience with study of data selected from several disciplines and organized to apply to practical problems and areas of living as well as experience with conventional disciplines, he can be helped to develop alternative structures for the handling of information. If he himself has experience in selecting data from more than one subject field and organizing them around a topic or problem he is investigating, he can gain some understanding of the nature and process of the multi-disciplinary approach (NEA, 1963, pp. 42-43).

A commitment to a statement such as this takes one well beyond the narrow subject-centered approach. It may take one further than he cares to go. Rosenbloom has even raised the possibility that such an approach might result in the achievement of goals that, until now, have been associated with the core curriculum (Rosenbloom, 1964, p. IX).

Summary. There are several guidelines which evolve from a commitment to a structured body of knowledge as a major source of content that affect the selection of learning activities. These guidelines are:

1. There should be a concern with major concepts and principles, rather than facts.
2. There should be an emphasis on the methods used by a discipline to treat data in its domain.

3. There should be a balance in the focus on structure and methods and a concern for their interaction.
4. The scope of the learning activities should be largely restricted to the domain with which the discipline deals.
5. The degree to which interrelationships with other fields that treat the same domain are studied should be determined by the degree to which the study of these other fields illuminate the major discipline.

DESIRED BEHAVIOR CHANGE OR OBJECTIVES OF INSTRUCTION

This section will deal with the selection of objectives of instruction. It will identify two issues involved and will present a rationale for selection of objectives based on learner behavior or task analysis, and will discuss how behavior change is a factor that must be considered when learning activities are planned.

A significant issue in curriculum development at the national or project level is whether the aims and objectives of such programs should be determined by the project staffs, or whether they should be determined by the schools who use the package produced by the project. One's stand on this particular issue must be tempered with an awareness of certain implications. If the stand is taken that aims and objectives should be determined at the national or project level, local control of schools is threatened. If the stand is taken that aims and objectives should be determined at the local level, it has to be recognized that very often those who work at the local level lack the desire, the skill, and the resources to do an adequate job.

Another issue concerns the process of determining objectives. A very prominently held belief among many of those concerned with curriculum development is that, unless those who have the task of teaching for objectives are actively involved in the process of determining objectives, they will not be personally involved and committed. If they are not committed to a set of objectives, they will simply go through the paces. The counter argument is that, given a package that explicitly states what students are to do as a result of instruction and the over-all objectives of a program that prescribes steps or methods to follow in order to gain these ends, teachers will do a good job because they will be freed from other responsibilities and demands on their time that normally prohibit them from spending the required time on planning and teaching. These questions are difficult ones with which to contend.

It is sometimes very difficult to determine the specific objectives of various curriculum reform projects. Goodlad was referring to this when he stated:

> . . .each curriculum project is free to formulate objectives for its own particular seqment of the curriculum. Rarely are these objectives defined with such precision that one would know exactly what to evaluate in determining the success of a program (Goodlad, 1964, p. 11).

He goes so far as to make the statement that "it is recommended that curriculum investigators, seeking funds for new proposals, be required to submit statements of . . .objectives as well as plans for evaluating their attainment" (Goodlad, 1964, p. 82). These statements of objectives should include a specific statement of the kind of behavior students will be able to perform as a result of instruction. The importance of objectives of instruction as a factor affecting the selection of learning activities may be summed up in the simple statement that "If you give each learner a copy of your objectives, you may not have to do much else" (Mager, 1962, p. 53).

The Industrial Arts Curriculum Project has taken the position that the best way of approaching the question of objectives is to determine the objectives for industrial arts at the project level, rather than at the local school level. If, as Mager states, one may in some cases only have to give the learner a copy of the objectives, objectives become a very important factor in determining learning activities. There should be a direct relationship between the kind of human performance specified in the statement of objectives and the kind of activity that takes place in the classroom when the objective is being met. Gagné makes this point clear when he states that:

> It is logical to suppose that the initial step in deciding on the conditions for learning is that of defining objectives. In terms of the system model, this means that for any given occasion on which the system is to perform its mission, there needs to be a decision about the nature of the change in behavior sought. Only if this is done will it be possible to infer what kind of input needs to be made to the learner, that is, what kind of learning situation needs to be established to bring about this change (Gagné, 1965a, p. 241).

He sees this process of determining the specific nature of the desired behavior change, task analysis, as having three implications for the selection of learning activities. These are: 1) that in terms of the learning process, different conditions of learning which should determine instructional methodology are required for different levels of performance, 2) the sequence of learning activities should be determined by the level of performance specified, and 3) a diagnostic assessment of student progress toward attaining certain behaviors can be carried on and the results of this assessment be fed back into the instructional process (Gagné, 1965b, pp. 20-21). Of these three, it seems the most important is to determine what conditions of learning must be present in order to have students perform at a certain level.

If, in the process of describing the specific level of desired terminal behavior, it becomes apparent that this behavior involves complex operations on the part of the learner, the designer of learning activities must insure that either the learner has previously been able to behave this way, or else he must provide the conditions within the learning activity that teach the learner to behave this way. Some higher level objectives, such as analysis, synthesis, and evaluation, can be accomplished by having the students do some very exciting problem solving and discovering; but it can be assumed that before they can perform at the higher levels in the hierarchy, they must be able to perform at the lower levels.

This process of task analysis is considered to be one of the most promising areas of educational research and one of the most appropriate ways of determining instructional sequences (Scandura, 1966, pp. 143-144). Task analysis should be carried on until it can be safely assumed that the learner is operating at the level to be reached. There is some evidence to indicate that determining the level at which the learner is now operating through the use of task analysis offers more insight into the ability of the learner to operate at higher levels than do some forms of aptitude and achievement testing (Gagné, 1962, pp. 355-365).

Another important way that objectives affect learning activities revolves around the degree to which learning activities contribute to the attainment of daily, unit, or yearly objectives and over-all school objectives. In the process of determining specific daily objectives through the use of task analysis, a very logical structure of objectives should result. At the top of the structure will be higher-level learnings or behaviors that are dependent on the subordinate learnings. The higher level, or more complex behaviors, are sometimes attained through more complex learning activities, activities requiring more than recall of fact. The logical structure derived through task analysis should provide information as to the type of subordinate or prerequisite learning activities that students must be able to do or must have experienced before they are subjected to the more complex learning activities requiring a great deal of independent thinking. For instance, before students can be expected to handle the operations required of them in complex games or guided and free discovery, they must be able to cope with the responsibilities inherent in such activities. These responsibilities can be learned through learning activities that are purposefully provided; that is, it is recognized that there are subordinate activities that make up higher order activities and these subordinate activities are planned.

Krathwohl has pointed out that there are three levels of objectives--the most general level relating to program planning, the intermediate relating to curricular planning, and the most specific relating to the development of instructional materials. He uses the phrase "entry behaviors" to refer to the type of behavior statement that is needed to aid in building instructional materials. In other words, what does the learner bring with him when he enters the program or a particular phase of the program? (Krathwohl, 1965, pp. 83-85). These entry behaviors should be determined.

Another very important product that comes out of the process of building instructional objectives is that it aids in preventing the simple mastery of subject matter from becoming the major objective of a course of study. Schools and school teachers are quite often textbook oriented, and covering the textbook as an instructional objective is an unfortunate by-product of this textbook orientation. By determining objectives through task analysis, and then building learning activities based on these tasks, there may be less chance that covering the textbook will be the major objective of a programmed study.

The staff of the Industrial Arts Curriculum Project made an attempt to determine objectives of instruction based on task analysis for the reasons implied above. The major references used by the staff were Mager's programmed text, Preparing Instructional Objectives (Mager, 1962); the three available taxonomies of education objectives, (Bloom, et. al., 1956), (Krathwohl, et. al., 1964), and (Simpson, 1966); and the learning sequence proposed by Gagné (Gagné, 1965a, pp. 31-61). A general framework was developed for writing objectives. This framework has borrowed from what leaders have set down as guidelines that should be followed.

The framework, presented in abbreviated form here, is a series of questions that was used to screen or check objectives as they were written by various staff members.

1. Terminology - Are objectives written in terms of student behavior that can be observed and measured? Are specific rather than vague verbs used to describe behavior? Have conditions under which behavior will be observed been specified?

2. Internal Consistency - Is a consistent general-to-specific pattern being followed? Are lower objectives subordinate to higher objectives?

3. Behavioral Consistency - Are behaviors in simple or subordinate objectives consistent with behaviors in complex objectives? Are they consistent with course objectives? With school objectives?

4. Criterion Level - Has the level of acceptable performance been specified? Have the conditions under which mastery will be demonstrated been stated?

5. Measurement Potential - Can the behaviors that have been described be observed and measured? Can valid test items be constructed?

6. Accomodation of Individual Differences - Are objectives sufficiently varied to allow for the great individual differences encountered in students of this age group?

Summary. The position has been taken that it is necessary for a curriculum improvement project to determine the objectives of instruction in terms of the type of observable behavior students will be able to perform as a result of instruction. It was pointed out that this can be done through a process of task analysis and that the results of such an analysis should directly affect the selection of learning activities. Selection of learning activities are affected in the following ways:

1. Conditions necessary for learning to take place at various levels of intellectual operation can be provided.

2. Sequences of activities can be better planned.

3. Diagnosis of student progress is facilitated.

4. Major aims can be kept in focus.

5. Preparation for complex learning activities can be provided.

6. Instructional materials will be in line with student capabilities.

7. Mastery of content, or simply covering the textbook, will not replace over-all aims.

NATURE OF THE LEARNER

The third major factor or condition affecting the selection of learning activities is the nature of the learner. This factor will be treated by a discussion of three major topics: psychobiological characteristics of early adolescents, motivation, and interests.

A great deal of information concerning the learner has been accumulated, but much of it is tentative. About the only thing that is known for sure is that human variability does exist. This complicates matters greatly; and when you put genotypic and phenotypic factors together with psychological, biological, and environmental factors, it is almost impossible to arrive at a description of the typical adolescent. People are different, and the schools must work with this difference.

Traditionally, schools have reacted to individual differences by varying programs and by trying to determine the age at which it is best to begin certain aspects of instruction. This latter reaction, the concept of readiness, is now being re-examined. Probably the most influential factor that has caused this re-examination has been the consideration of the "spiral curriculum" as expressed in the statement by Bruner that anything can be taught to anyone at any time in an intellectually honest form, as long as it is presented at his level (Bruner, 1960). Three-year-olds are now being taught to read, where before the best "evidence" we had was that children were best introduced to reading when they reached a particular mental age. All kinds of exciting things are now being accomplished in the elementary school that were formerly treated in college. We do not, in fact, know whether any given student is ready to learn any given thing, but some researchers say the odds favor the student's readiness. The traditional educational concept of readiness has been seriously challenged and perhaps should be modified or rejected.

However, rejection of this principle in whole would perhaps be unwise. The implication of such action is that all we would have to do would be to do a very thorough job of presenting information at certain specified levels and with certain techniques, and everyone would learn. This is not the case. Students determine their readiness for themselves, if learning experiences are available. It must be kept in mind that people are different and that, in some cases, the spectacular results that were achieved with some of the practices that tend to reject the traditional concept of readiness came about because of very extensive expenditures of money. Some spectacular innovations have been reported that involve machines costing $40,000 per pupil-station, with a pupil-teacher ratio of one pupil for every three teachers.

Psychobiological Characterists of Early Adolescents. Fundamentally the following ideas and suggestions are a recognition of the fact that there are psychological and physical changes associated with early adolescence which are of great significance to those developing a course or program for junior high school students. Important characteristics may be categorized under three headings: physical development, cognitive development, and social development.

Physical Development. A person has three principal growth periods, each of which has certain distinguishing characteristics. Infancy includes the extremely rapid prenatal phase and the deceleration phase toward the end of the second year for most infants. Childhood is a period when physical growth proceeds at a moderate and constant rate. Clearly marked phases within or between periods are generally not evident except that near the end of the childhood period there is a "preadolescent lag" which is often marked by very slow physical growth. This lag characteristically marks the transition from childhood's slow and steady development to adolescence's more rapid and also more irregular growth. During this transition, the body is adjusting to a new chemistry of growth.

The "preadolescent lag" is likely to be followed by a prepubertal spurt. A child who develops early with respect to one feature generally develops early in respect to others (Tanner, 1958). However, inconsistencies are frequently shown in the lag of one function as compared with another. Growth in strength, for example, generally lags behind growth in body size (Jones, 1949). Adolescent awkwardness with its sometimes embarrassing uncertainty in motor skills probably results from unmeshed growth patterns within the individual. Basal metabolism may fluctuate greatly and the early adolescent may tire easily. All of these inconsistencies in growth within the individual may make this a most trying time both for him and for parents and teachers who try to work with and understand him.

So far our discussion has been about the intra-individual variability of physical growth patterns which may result in difficulties for the individual and others. These difficulties or challenges are greatly magnified for the educator by the inter-individual differences in growth patterns. Not only are the growth patterns within an individual not always well correlated, but the over-all patterns of different individuals which produce inter-individual differences are likely to show immense variability.

Many illustrations of inter-individual differences might be cited. For example, although the peak of growth is reached at about 14 years in boys and is responsible for an average gain in height of about eight inches, it may occur during any period between 12 and 17 years; and the gain in height may range from 4 to 12 inches. In girls on the average the adolescent spurt begins at about age 12, ends earlier, and is smaller in magnitude than that of boys (Jones, 1962).

Although height and weight variabilities in growth patterns are very significant, it should be recognized that there are other very important related but more covert types of intra- and inter-individual variabilities which are of as great or greater significance during the junior high school age period: the speed at which the heart grows, the strength of the muscles, the vital capacity of the lungs, also the hormone production of the endocrine glands produce chemical changes of amazing complexity in the body. The chief endocrine glands are the thyroid, pituitary, parathyroid, adrenal, gonad (in part), pineal, thymus, pancreas (in part) and the liver (in part). If any of these glands or a combination of them are hyperactive or hypoactive, then unusual and potentially serious behavior changes are likely to be exhibited. For example, underfunctioning of thyroid gland tends to produce, among other things, lethargy, diminished metabolism, and overweight. On the other hand hyperfunctioning of the thyroid produces over-stimulation of the body tissues resulting in increased pulse, loss of body weight, and heightened nervous tension (Blair _et.al._, 1962).

Both intra- and inter-individual variations in growth patterns have been noted. The interactions of a great variety of factors produce these variations in the intensity, velocity, and magnitude of adolescent growth. Among these, in addition to those already suggested are: genetic and constitutional factors, diet, climate and region, and social status (H. Jones and M. Jones, 1962).

Basic motor patterns seem to appear during early childhood and improvement in these are a result of experience (Glasson, 1960). Motor performance scores increase with age. These increases characteristically represent a combination of interacting elements: development of the nervous system, of the muscular system, and of the skeletal system.

In industrial arts, junior high school teachers often expect student readiness sufficient to learn manipulative processes requiring complex finger coordination. Evidence would indicate learning experiences should be screened to provide large muscle coordination rather than complex finger coordination at that school level (Fuzak, 1958).

Although relatively little is known about motor development, the following conclusions seem justified: 1) individuals at a particular age vary immensely in the degree of motor development with differences increasing with age, 2) the relative position of an individual in a group is fairly stable from the second grade through high school, and 3) the effect of the environment is greatest in the period of the most rapid normal development of the characteristic and it is least in the periods of least rapid development (Bloom, 1964).

These data on physical development suggest that the following be kept in mind in the planning of an industrial arts course sequence for junior high school pupils:

1. Since early adolescence is a transition growth period it must be expected that individual physical skills may vary considerably from month to month.

2. Within each class there will be individuals in widely differing stages of physical development. Hence, care must be taken in planning activities to adjust to these great differences.

3. Since much awkwardness in early adolescence would be expected, activities requiring too precise and fine motor skills should be minimized or the standards maintained should take probable difficulties into account.

4. The growth spurt and its frequent concomitants of rapid tiring and lethargy suggest the need for a program of activities which is elastic enough to allow for those with a low energy level as well as those who currently may have a high energy level.

5. A program of activities should avoid too great an environmental stress during this period of transition which is likely to produce many of its own internal stresses.

Cognitive Development. Factors of most significance in the cognitive area in developing an industrial arts program for junior high school students are: 1) types of intellectual development, and 2) amount of variability within the early adolescent groups.

Early in the Twentieth Century E. L. Thorndike said, "Anything that exists can be measured." Since that time psychologists, educators, and personnel workers have been aggressively pursuing the measurement of mental abilities. While much in the area still remains unexplored, there are many ideas which have been developed and checked. These can be used as one basis for program development.

Intelligence tests are designed to determine an individual's capacity to learn. In school, such tests are helpful in determining how rapidly and at what level a child can achieve. Essentially such tests are designed to measure an individual's behavior in situations for which he has not been specifically trained. In one sense, of course, intelligence tests are composite achievement tests. They differ from regular achievement tests in that they sample achievements which are partially independent of formal schooling. Some idea of the contents of intelligence tests is suggested by the following types of items covered by intelligence tests (Blair, et. al., 1962):

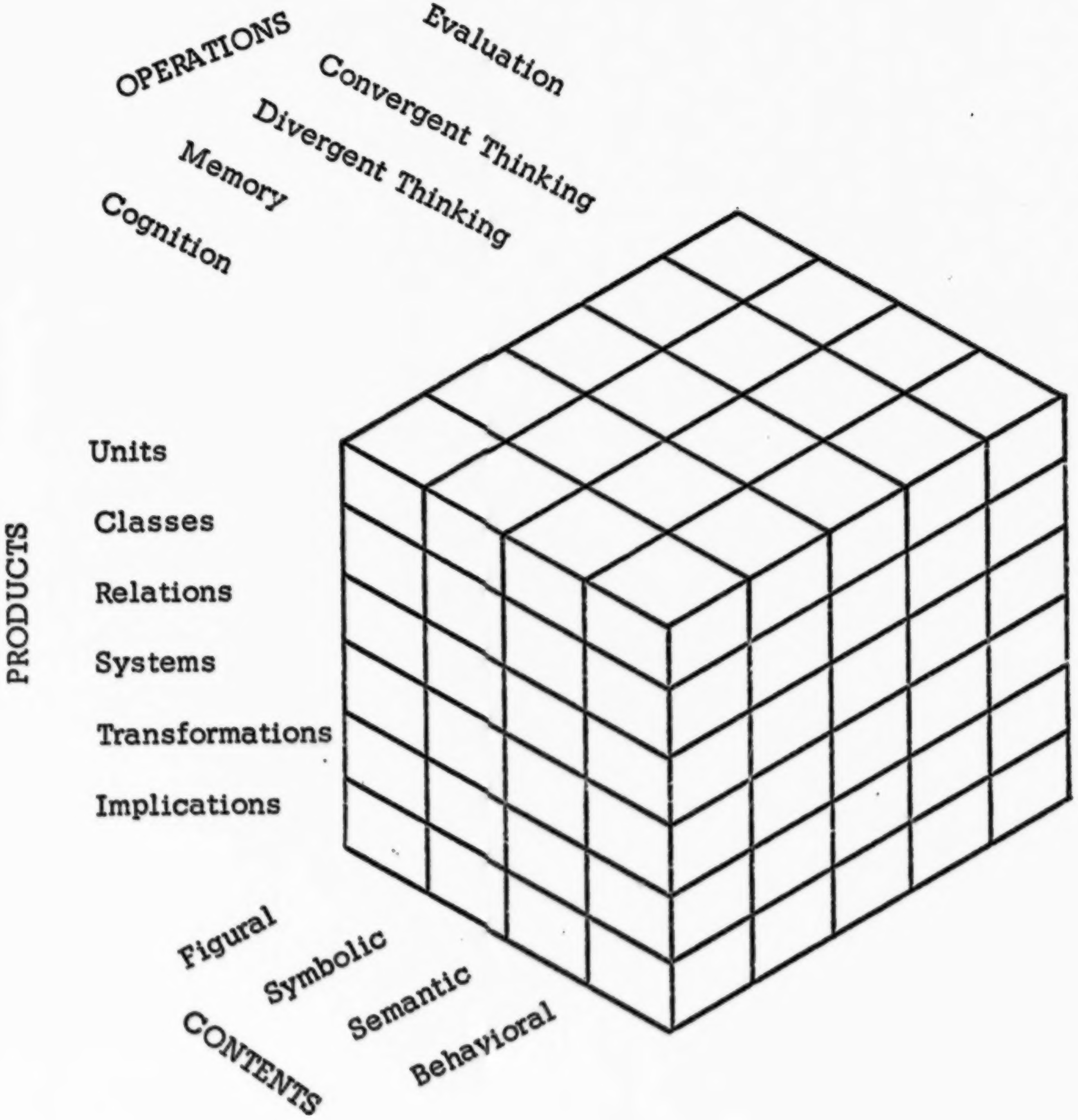
1. Following directions
2. Ideational memory
3. Vocabulary
4. Space perception
5. Memory of numbers
6. Memory of sentences
7. Memory of stories
8. Abstract ideas
9. Memory of form
10. Analogies
11. Number series
12. Aesthetic Judgment
13. Drawing
14. Abstract reasoning
15. Completion
16. Reorganization

The 16 items above also suggest areas of mental activity which may appropriately be included in a course or program pattern.

Another way of looking at the amazing complexity of the human intellect is shown in Figure XXXII. Along one dimension are found the various kinds of operations, along a second one are the various

Figure XXXII

A CUBICAL MODEL REPRESENTING THE STRUCTURE OF INTELLECT
(Guilford, 1959, p. 470)


OPERATIONS
Evaluation
Convergent Thinking
Divergent Thinking
Memory
Cognition
PRODUCTS
Units
Classes
Relations
Systems
Transformations
Implications
CONTENTS
Figural
Symbolic
Semantic
Behavioral

kinds of products, and along the third dimension are the various kinds of content. This produces 120 cells, each of which may be thought of as a factor of intellect. This model emphasizes the fact that intelligence should not be thought of as one analyzed factor. Rather, it is an extremely varied combination of factors. Note that psychomotor variables are not clearly considered in this model.

Achievement tests have been designed to measure a great variety of skills and subjects. Some of these are general batteries designed to get an over-all picture of the individual's achievement. These are called general achievement batteries. Some of the more specific types of achievement tests which may be useful to the program developer and to the teacher in industrial arts are: vocabulary tests, mathematics tests, business education tests, industrial arts tests, listening comprehension tests, reading tests, study skills tests, physical science tests, social studies tests, economics tests, and specific vocations tests. A very comprehensive listing of these tests may be found in Tests in Print (Buros, 1961). Reviews of tests by experts are found in the Mental Measurements Yearbook Series (Buros, 1965).

In addition to knowing the nature and measurement of intelligence and achievement, one should be cognizant of the variability of individual achievement which may normally be expected within a seventh-, eighth-, or ninth-grade group. Figure XXXIII suggests a normally anticipated range of general mental ability and of reading ability of a seventh-grade group of 100 students.

Figure XXXIII

DISTRIBUTION OF MENTAL GRADE LEVELS AND OF READING GRADE LEVELS OF 100 SEVENTH-GRADE STUDENTS
(Adapted from Simpson, 1966)

General mental grade level	Number of students with mental age at this level	Reading achievement grade level	Number of students reading at this level
12	1	12	2
11	3	11	2
10	7	10	6
9	12	9	13
8	17	8	15
7 Average	20	7 Average	20
6	17	6	18
5	12	5	14
4	7	4	5
3	3	3	4
2	1	2	1
Totals	100		100

One goal of any seventh-grade program should be to have sufficiently difficult activities to challenge those with senior high school abilities and have other activities appropriate to those with average early elementary abilities.

Characteristic educational patterns and practices were developed long before the type of data shown in the table above had been systematically determined. This fact plus "educational lag" account for the reality that many current educational practices are far out of line with what is now clearly known about the nature of individual differences in mental capacity and in cognitive achievement levels.

In view of the facts about cognitive development and its great variability within an early adolescent school population the following points seem relevant for junior high program development:

1. The activities in the program should be varied enough to encourage the continuous development of many cognitive dimensions.
2. Programs should be extremely varied in difficulty level so that the lowest fourth of the classes will not be lost and the highest achievers will not be bored by the lack of challenge.
3. Since no program can entirely plan for the needed activities of every individual, much thought should be given by program planners through options and by other means to encouraging the individual to help plan his program. The general program should set the over-all plan of activities, but should not be so straight-laced as to disregard the striking individual differences which have been described above.

Social Development. In a program devoted primarily to cognitive and psychomotor learnings, why should one be concerned with social learnings? The primary reason is that an individual's success or lack of success in his social learnings is likely to have very significant effects upon the quality and quantity of his cognitive learnings and his psychomotor learnings. Hence, the program developer and the teacher cannot afford to disregard the social development of the individual.

Early adolescence marks the beginning of a transition period from childhood roles to adult roles. This transition characteristically involved some weakening of the role of the family and a pronounced strengthening of ties with other early adolescents. Hence, while the early adolescent strives for maturity, he is likely to be somewhat insecure and is seeking a social basis for a new type of security outside the home.

In the elementary school years boys are likely to be "preoccupied with their own small groups in rough-and-tumble play, and the girls in vigorous but less combative activities. . .shortly before pubescense, and for a period of about two years thereafter, the spontaneous social groups are almost entirely unisexual" (Blair and Jones, 1965). In the pre-adolescent period responses to sociometric testing in a class frequently show no boy has chosen a girl on any of the social or task categories.

Peer groups tend to increase in size as the children become adolescents. When a particular child is not able to find a congenial group to which to belong, he is likely to show signs of unhappiness, excessive sensitivity, and defensiveness. Rejection by peers tends to result in loneliness and shyness which can have debilitating effects. School activities should be geared to involve each youngster in frequent and congenial task activity. Such group involvement not only aids the social adjustment of the individual to his peers but also significantly facilitates the cognitive learnings in which the teacher may be primarily interested.

In early adolescence socialization is largely a process of each individual finding his own role. In many schools the problem is accentuated by the change from the self-contained classroom of the elementary school, with one teacher, to a departmental arrangement. In the departmental setup the student must relate to about a half-dozen teachers and a much larger student body than that to which he is accustomed. To the emerging struggle for independence and to a changed body image the school adds new problems of human relationship. All this tends to produce social and sometimes personal instability in the early adolescent period. In view of the fact that this is a transition period, there is likely danger ahead when the junior high school is handled as a small scale senior high school.

Some of the specific social difficulties likely to be faced by the early adolescent are reported by Gordon: making friends, learning the rules, becoming acquainted with new teachers, understanding the work, belonging to the right group, going the right place, wearing the right clothes, and participating in extra-curriculum activities (Gordon, 1962). Any or all of these difficulties may favorably or adversely affect course work. Whether the effects are positive or negative depend to a large extent on the types of course activities which teachers encourage.

Possible implications of the foregoing for an industrial arts program are the following:

1. The interaction between social and intellectual development must not be disregarded.
2. The program should be set up so that peer leadership can be both identified and developed to utilize normal social patterns of early adolescents.

3. The many and varied social problems of the early adolescent should be recognized, since these will affect the quantity and quality of desirable cognitive development which will ensue.

4. Much use of peer groups, frequently with help from peer leaders, should be utilized.

5. Attention should be given to involving each student in activities where he comes into healthy contact with many of his peers.

6. In the age when roles are likely to be changing for students, considerable use of role playing in the program would seem appropriate. Also exemplars of individuals successful in occupational roles can appropriately be used.

7. The following types of group activities are likely to augment individual study: laboratory work, school projects, visits to manufacturing plants and to construction sites, and field trips to industrial museums.

Motivation. There are several approaches that might be used to discuss the question of motivation. A first approach might be to analyze the research that has been undertaken in laboratory situations involving sub-humans and humans, and in field situations such as schools and industry. From this analysis, one might be able to come up with a series of statements that would be adequate hypotheses as to what motivation is. This would not necessarily be helpful to one building learning activities and it would be difficult to select out those studies that are relevant to schools.

A second approach, the one used herein, is to make a decision as to the most relevant and treatable aspects of motivation that relate to instructional processes and present hypotheses or hunches that seem to be supportable. These hunches must offer directions to persons who determine instructional processes; presenting data is not sufficient.

Two very important factors that affect motivation must be considered. They are: 1) students are *required* to be in school, and 2) many students have had limited success experiences in their previous schooling. These may have convinced them that staying in school is not worthwhile. There is no simple way to take someone who lacks motivation and who would rather not be in school and make him an eager, excited learner. There are, however, conditions that *tend* to aid in increasing the level of motivation of students in the classroom. The literature on how to provide these conditions is somewhat vague. Quite a bit of the advice is similar to such tautologies as "You motivate a student by motivating him."

Gagné sees the teacher as being in the position of haveing an effect on motivation only after the child comes to his classroom. There is little he can do about how the child is when he gets to the classroom; he has limited access to this aspect of the child's environment. He can, however, affect the desire of the child to engage in learning and his desire to continue to engage in learning (Gagné, 1965a, pp. 207-214).

Gagné recognizes two conditions as being necessary to motivate the child to engage in learning. One of these is alertness; the child must be in a state where the neural centers of his brain that deal with attentiveness are operating (Gagné, 1965a, pp. 209-210). Woodruff also sees alertness as being important and feels that the student's adjustment affects alertness. This can be seen in his statement that:

> A student who has a seriously disturbing conflict which he has not yet resolved may be said to be maladjusted. His conflict will have such a hold on his attention that he will be unable to turn attention fully and effectively to his regular duties (Woodruff, 1961, p. 199).

The second of these conditions necessary for engaging in learning, according to Gagné, is motivation to achieve. The most significant or successful type of action here seems to be that which conveys a conception of action. The student must be able to see what he can do as a result of a particular lesson and value it. A second consideration here is that when specific action cannot be seen, it is up to the teacher to provide some form of adult guidance that allows the student to see that large or more general outcomes can result through an accumulation of more specific actions (Gagné, 1965a, pp. 209-212).

The importance of having specific objectives is seen here. The fact that the student can see what his terminal behavior will be might serve as a motivating factor. Some of the work by Flanders indicates that the way in which a teacher clarifies goals affects achievement and also the relative degree of independence proneness on the part of students.

Flanders' work implies that there are times when students themselves should be allowed to clarify ambiguous goals (Flanders, 1960).

Assuming that the student can be made alert and can be motivated to achieve, the problem becomes one of maintaining this interest on his part. Gagné sees this resulting when the student gets feedback that he is making progress in learning sub-tasks and when he begins to enjoy learning. Essential to this enjoyment is the requirement that the student be helped to set reasonable standards by which to judge himself and is aided in building for himself a style of attacking new learning situations that allow him to be successful (Gagné, 1965a, pp. 212-214).

The above aspects of motivation seem to be those over which the teacher has the most control. Closely tied to these will be the principles that underlie the instructional techniques that will be employed.

Interests. The major question concerning interests is whether one teaches about what pupils are interested in, or whether one makes pupils interested in what he is teaching. There have been some curriculum movements that have attempted to make the former, the interests of pupils, the criterion by which objectives, methods, and materials have been selected.

A curriculum based on a structured body of knowledge cannot by definition be based solely on the interests of children. This does not mean that interests play no part---because they do---especially in the selection of learning activities. Ausubel takes a very critical look at curricula based solely on interests; he says that 1) there is no evidence to indicate that children are sensitive to their own developmental and psychological needs, 2) there is little evidence to indicate that what children feel they need is indicative of what children really need, and 3) it cannot be assumed that children's spontaneously expressed interests and activities give a true picture of all their needs and of all their potential capacities. He concludes that:

> . . .the current interests and spontaneous desires of immature pupils can hardly be considered reliable guideposts and adequate substitutes for specialized knowledge and seasoned judgment in designing a curriculum. Recognition of the role of pupil needs in the school learning does not mean that the scope of the syllabus should be restricted to the existing concerns and spontaneously-expressed interests that happen to be present in a group of children growing up under particular conditions of intellectual and social class stimulation (Ausubel, 1963, p. 11).

He recognizes that when pupils evidence felt needs to gain knowledge as an end in itself that achievement is greatest. He, however, believes that this type of need is acquired or learned, and is developed through stimulating education. They are acquired ". . .largely through exposure to provocative, meaningful and developmentally appropriate instruction" (Ausubel, 1963, p. 11). "The motivated student, . . . reflectively considers, reworks, and integrates new material into his cognitive structure irrespective of how he obtains it" (Ausubel, 1963, p. 12).

It would seem then that interests of pupils should serve as a force that affects curriculum decision and that interests are something to be cultivated. There is some question as to whether interests should serve as the prime determinant in this decision-making process.

Summary. Several factors relating to the nature of the learner that should and do affect selection of learning activities have been illustrated. Perhaps the following statement by Cronbach serves as a useful summary:

> Readiness is created, cumulatively, by a proper combination of content and method. . . The main point for us to notice is that what pupils can understand at any age depends upon how you explain it--upon that, and upon what their background has been. It is this that justifies my initial remark that no question about readiness can be given a general answer (Cronbach, 1964, p. 29).

SCHOOL FACILITIES AND MATERIALS

Facilities and materials in the industrial arts laboratory setting are definite factors to be considered in the selection of learning activities. The question becomes one of whether the major force should be what is already existent in the typical school, or what should be according to the design of the "package" developed by the curriculum project.

If the decision is made to base the learning activities on present or available facilities and materials, there are several serious drawbacks: 1) it is extremely difficult to collect data and to arrive at a description of what is typical; 2) data collected on schools are quite often outdated by the time that they are published; 3) most surveys of existing conditions are samples of what exists and the samples may be inadequate; and 4) curriculum reform projects usually are intended to radically change what already exists, rather than replicate; so in some cases it does not make too much difference what exists because conditions are going to be changed anyway, or else the package cannot be used successfully.

There are several basic environmental or administrative conditions that need to be considered. These are: 1) time, 2) space, 3) available equipment, 4) raw materials available, and 5) money.

Time is a very important factor, for it would do little good to develop a program that required ten hours of class time per week for forty weeks if it is found that most schools are only willing to devote five class periods a week to the program and the school year is only thirty-six weeks in duration. A typical criticism of curriculum improvement projects is that as assumption is made that the project has produced the only worthwhile course being offered in the schools; therefore, time should be taken from other less important subjects. Class period time requirements should be reasonable and should probably not exceed what is generally the minimum period length usually found in schools. As to the number of days in the school year, a project should meet this problem by providing options or branches that can be used to provide supplemental activities for those days that exist in some states over and above a certain core or base.

Available space, both in its qualitative and quantitative aspects, affects program and therefore is directly related to learning experience selection. This factor can be controlled by careful selection of the participating schools.

Other factors of equipment, raw materials, and budget must be considered in the selection of pilot schools; however, these factors can be adjusted by the use of Project funds.

Summary. In summary, the factors of time and space will be determinants to be carefully considered. If only limited equipment, supplies, or budget are available, these factors can be more easily countervailed through expenditure of Project funds.

INSTRUCTIONAL PROCEDURES AND MATERIALS

Instructional procedures and materials as factors affecting the selection of learning activities will be discussed in two parts. The first part will deal with Teacher Characteristics, and the second with Instructional or Methodological Theory.

Teacher Characteristics. In a recent review of research regarding characteristics of teachers, Ryans listed well over seventy-five variables that have been investigated in the past five years with some degree of sophistication in terms of research design (Ryans, 1963, pp. 434-435). There are undoubtedly more than seventy-five identifiable characteristics, and to account for them all would be a difficult task.

As with most of the other factors considered in this rationale, there are several alternative positions that can be taken. One alternative is that of determining what the typical teacher is like and then building learning activities that are commensurate with his capabilities. A second alternative is to build learning activities and then allow only those teachers who measure up on certain standards or characteristics to use the prepared package. A third alternative is to build the best package possible and not worry whether teachers are capable of using it. The fourth alternative is to keep in mind what teachers are like, build a package, and then train the teachers to handle the package with emphasis in training being on those teacher characteristics that have the most effect on teacher behavior and that can be improved. A fifth alternative is that teaching is an art, and that it is the right of the individual to decide for himself what and how he is going to teach.

The fourth choice seems to be the most tenable in terms of considering teacher characteristics when learning activities are determined for a course in industrial arts based on a structured body of knowledge. There are four (4) more or less general characteristics that can be used as reference points when giving reasons for this particular choice. Reasons for rejection of the other alternatives should appear as the discussion progresses. The four major teacher characteristics of concern are: 1) knowledge of subject matter, 2) values and attitudes, 3) methodological skill, and 4) concept of self.

Knowledge of Subject Matter. Knowledge of subject matter is definitely a force where curriculum improvement projects are concerned. In the case of the Industrial Arts Curriculum Project, this is even more the case since the content of the revised industrial arts will be considerably different from the traditional offerings. This fact eliminates several of the alternatives above, since at the present time the typical industrial arts teacher knows very little about the concept of structure, let alone the structure of the body of knowledge of industrial technology. This means then that some sort of re-training program will have to take place, and/or pre-service teacher education programs in industrial arts will have to change their curricula.

Before teachers can be expected to guide learning activities concerning this structured body of knowledge, they must first be taught what it is. This will involve building elaborate teacher handbooks or guides that deal with the various concepts involved and that communicate the structure. Quite possibly, if funds are available, these guides can be supplemented with summer institutes or in-service programs that, among other things, focus on structure. However, it must be taken into consideration that funds for institutes and other training programs may not always be available. For this reason, great emphasis should be placed on pre-service programs and on text-type materials.

Values and Attitudes. The human characteristic to resist change has been documented many times, as has the characteristic of teachers to resist curriculum change. There are various reasons for this resistance on the part of teachers. A basic reason is that they value the way things are presently done. There are several underlying reasons for their making this sort of value judgment, and these reasons should be examined when a curriculum project that is going to force a change in these values is being conceptualized.

A first reason might be the belief that the present way of teaching a subject, in this case industrial arts, is the best way. The teacher feeling this way may honestly believe that what is going on now is good and he gets a great deal of satisfaction out of doing it. This person is professionally committed. He sees greater value in his program than in the proposed new curriculum program. In addition, he may not be convinced that the new program will work, whether he or anyone else can be successful in its implementation. This latter doubt is made all the more significant to him by the fact that many curriculum proposals in recent years have come from persons who have not had recent personal experience trying to do what the teacher is himself called upon to do daily.

A second reason for such a value judgment might stem from the fact that a teacher is very comforatable doing what he is presently doing and sees the innovation as being too difficult for his students, but quite often he may feel that it is too difficult for him to learn. He may not care to place the authority role that he plays in the classroom in any kind of jeopardy.

A third reason might be that a teacher has invested a great deal of time and effort convincing the administration and board of education in his school that the expense of building and equipping an adequate laboratory is worthwhile. He now has good facilities and he does not feel justified to ask for an additional change in curriculum that may well result in some present facilities not being used for weeks at a time.

A fourth reason might be that the teacher is not committed to any kind of a program or even to teaching. He may be one who is teaching only because he failed to succeed in some other major in college, or he may be teaching in order that he might coach. This lack of ability and lack of commitment are very real problems, and they should definitely be taken into consideration when learning activities are selected and when instructions and guides for teachers are developed.

Methodological Skill. A third characteristic of teachers is their ability to use certain teaching methodologies. It cannot be assumed that just because a particular method is used by most teachers that it is being used properly. If one recalls or re-examines the different types of value structures presented above, he becomes even more doubtful. The fact that the backgrounds of teachers vary so widely also negates the possibility that they can all perform selected teaching operations efficiently.

Because of this wide variance in terms of skill, very careful consideration must be given to the different training devices that are planned. The ability of the various teachers to carry out and perform certain kinds of teaching strategies may well be the most significant variable insofar as success of the Project is concerned.

Concept of Self. The fourth characteristic to be discussed is a teacher's self-concept. A person's self-concept might be defined as his preception of himself, the feelings he has about himself, or the way he sees himself in the eyes of other people who to him are very important people. If one looks at the change that teachers who are going to be using a new curriculum package must make, it is not difficult to visualize that the innovation may raise or create very negative feelings about their own abilities. The new project may be very threatening, and the typical human response to threat is defensive behavior. Defensive behavior is characterized by a distortion of stimuli, or a distortion of what is received, and often the individual tends to mis-perceive that which threatens him. He becomes involved in protecting himself and clings, at times desperately, to that which, in the past, gave him a sense of accomplishment and security. Anything that threatens to take away that which in the past provided success is perceived as threatening and is therefore distorted. The more negative a person's self-concept, the more prone he is to distort reality and to react defensively.

It should be obvious then that one does not get an individual to change his values or to change his beliefs or to change his self-concept by condemning what already exists. One changes when he perceives the new situation as offering him more chances for success or self-enhancement than does the old. That which is new must not be perceived as threatening to that which is presently held in high esteem. The risk of putting the person who is to change on the defensive should be avoided.

If one accepts this view regarding the nature of change, the process that is developed to change the values and the behavior of industrial arts teachers will not be one that proceeds by tearing down that which presently exists. The new package must offer more to the teachers than they are getting from the present programs. If a change in values is to occur, that which is to be valued must be very attractive. If they are threatened by the new program, they will not perceive it as being beneficial; they will distort its meaning.

Instructional or Methodological Theory. In addition to teacher characteristics, one's theory of teaching serves as a factor affecting the selection of learning activities. Theory building involves the structuring of hypotheses or guesses as to the way some sort of phenomenon does or should occur. In the case of teaching, this would involve structuring hypotheses as to how one believes desired behavior changes in pupils can best be brought about.

In the past, a very common approach to building learning activities was to attempt to implement in the classroom what the *learning* theorist had hypothesized or observed in laboratory situations. This implementation has been difficult and relatively fruitless. A fairly recent move has been toward building a *theory of instruction*, rather than a *theory of learning*. An assumption is that in a theory of instruction, you control teacher variables.

Gage has stated that:

> Teachers must know how to manipulate the independent variables, especially their own behaviors, that determine learning. Such knowledge cannot be derived automatically from knowledge about the learning process. To explain and control the teaching act requires a science and technology of teaching in its own right (Gage, 1964, p. 273).

Many others have expressed concern over this same question. Hilgard was also concerned about using learning theory when he wrote:

> Technology must respect theory, in that it cannot violate fundamentally established principles, but theory never dictates technology directly. Learning theory will not dictate instructional practices any more than the principle of thermodynamics dictates whether airplanes shall be driven by propellers or jets. . . .Learning theory is likely to produce some economy in educational experimentation by suggesting direction in which answers can be sought, thus saving a wasteful empirical search (Hilgard, 1964, pp. 403-404).

Morrisett brings this one step closer to curriculum development when he states that "Learning theory may contribute importantly to a theory of instruction, but a theory of instruction must contain propositions that are applicable in curriculum development and teaching" (Morrisett, 1966, p. 125).

Ausubel probably sums up why, in the past, attempts to make direct application of learning theory to classroom procedures have been less than satisfactory. He indicates that the tendency of educational psychologists to extrapolate laboratory research findings to the classroom environment accounts for a great deal of our lack of knowledge about classroom learning. He believes that the classroom is different from the laboratory and that:

> . . .new variables are added which may qualitatively alter the general principles from the basic science to such an extent that, at the applied level, they only have substrate validity but no explanatory or predictive value (Ausubel, 1963, p. 6).

Such statements support the need for the development of a theory (or theories) of instruction. Gage suggests basing this theory on an analysis of : (a) types of teacher ability, (b) types of educational objectives, (c) components of the learning process, and (d) families of learning theory (Gage, 1964, pp. 275-276). The need for such a theory was pointed out by Roberts, who reviewed what has been accomplished in curriculum development and experimentation. He made the comment that very few of the attempts to develop improved curriculum designs were related to a comprehensive design or to a theoretical framework of learning or teaching (Roberts, 1966, pp. 353-361).

Stolurow recommends an approach that is scientific in nature. Rather than have research that describes characteristics of teachers and the relationships between characteristics, he suggests that necessary and sufficient teacher behaviors be specified and studied:

> . . .a model of teaching must be developed that will do at least two basic things. First it must make the large set relationships explicit. Second, it must permit the correction of mistakes made in trying to find out about teaching and indicate the nature of the required corrections (Stolurow, 1965, pp. 229-231).

The reminder of this discussion on instructional or methodological theory will be an attempt to: 1) present a model of instruction for the Industrial Arts Curriculum Project, and 2) discuss generalizations and ideas taken from theories of learning and suggest implications for the over-all strategy and for specific elements of the model of instruction.

A Model of Instruction. A traditional argument in education concerns whether teaching is an art or a science. Gage has made the point that this does not have to be an either-or situation:

> Although teaching requires artistry, it can be subjected to scientific scrutiny. The power to explain, predict, and control that may result from such scrutiny will not dehumanize teaching. Just as engineers can still exercise ingenuity within the theory of thermodynamics, teachers will have room for artistic variation on the theory that scientific study of teaching may establish (Gage, 1964, p. 271).

Another source of controversy is whether or not teachers should be bound by a fairly rigid structure within which he can operate, or whether they should be allowed to conduct lessons more or less extemporaneously. Jackson has made reference to two stages of teaching. One stage is what he calls preactive and is carried on prior to the time the students enter the room. It is very rational and deliberative. The other stage he refers to as interactive. It occurs when the teacher is in front of the students and is more or less spontaneous due to the effect of the students being present and the rapidity of events. Due to these conditions in the interactive stages, teachers tend to base their actions on feeling or intuition rather than thinking. He has found that a teacher must make in the neighborhood of 1,000 decisions a day in the interactive stage (Jackson, 1966, pp. 12-14). If this is the case, if teachers have to make this many decisions, controlling what a teacher does in front of his students becomes very difficult, yet very important.

In the case of the Industrial Arts Curriculum Project, which will be very highly structured, and in which content, objectives, and methods are "givens", it becomes very important that the variables be identified and a model of the instructional process constructed. With such a highly structured course, it becomes very necessary to plan ahead of time the specific events that should lead to attainment of objectives. Gagné is very insistent that conditions for learning be purposefully planned for and implemented. He sees the following advantages resulting from detailed planning of activities that provide conditions for learning to occur:

1. The selction of proper learning conditions may be made as an unhurried choice, rather than in "spur of the moment" decisions.

2. A "quality control" of the choice of learning conditions is ensured and maintained. Quality does not suffer from variations in teachers' skills.

3. Predesign makes possible pretesting. Whether or not a set of learning conditions has been correctly chosen and designed can be determined by trying it out on students and revising if necessary.

4. Predesign of learning conditions greatly reduces the necessity for the teacher to use valuable time in extemporaneous design, and thus makes it

> possible for proper emphasis to be restored to the teacher functions of managing instruction, motivating, generalizing, and assessing (Gagne, 1965, p. 253).

In order to illustrate the means or general methodological strategy of the Industrial Arts Curriculum Project, the following models have been adapted and constructed. The first of these, Figure XXXIV, describes the over-all teaching process. In this model it can be seen that there are three basic phases: planning, teaching, and evaluating, with two feedback loops. One loop is intended to affect the selection of objectives and the other to affect the selection of learning activities. This model can be broken down into yet another model, and this would be the general daily strategy employed by the Industrial Arts Curriculum Project (See Figure XXXV). This model is composed of the types of learning activities that will generally occur in a day's time or for a particular principle or concept. It involves several basic processes on the part of students: reception, selection, problem-solving, application, synthesis and evaluation. The capital letters by the side of the various stages in the Instructional Model refer to the mental processes that are involved in these stages. These processes are based on similar processes outlined by Woodruff:

A Reception and perception of referents resulting in meaningful sensory impressions or percepts.

B Formation of a clear, organized concept with its terminology.

1. Differentiation - Recognizing clearly
2. Integration - Identifying functional relationships to other things

Figure XXXIV

TEACHING PROCESS MODEL
(Adapted from Hough and Amidon, 1966)

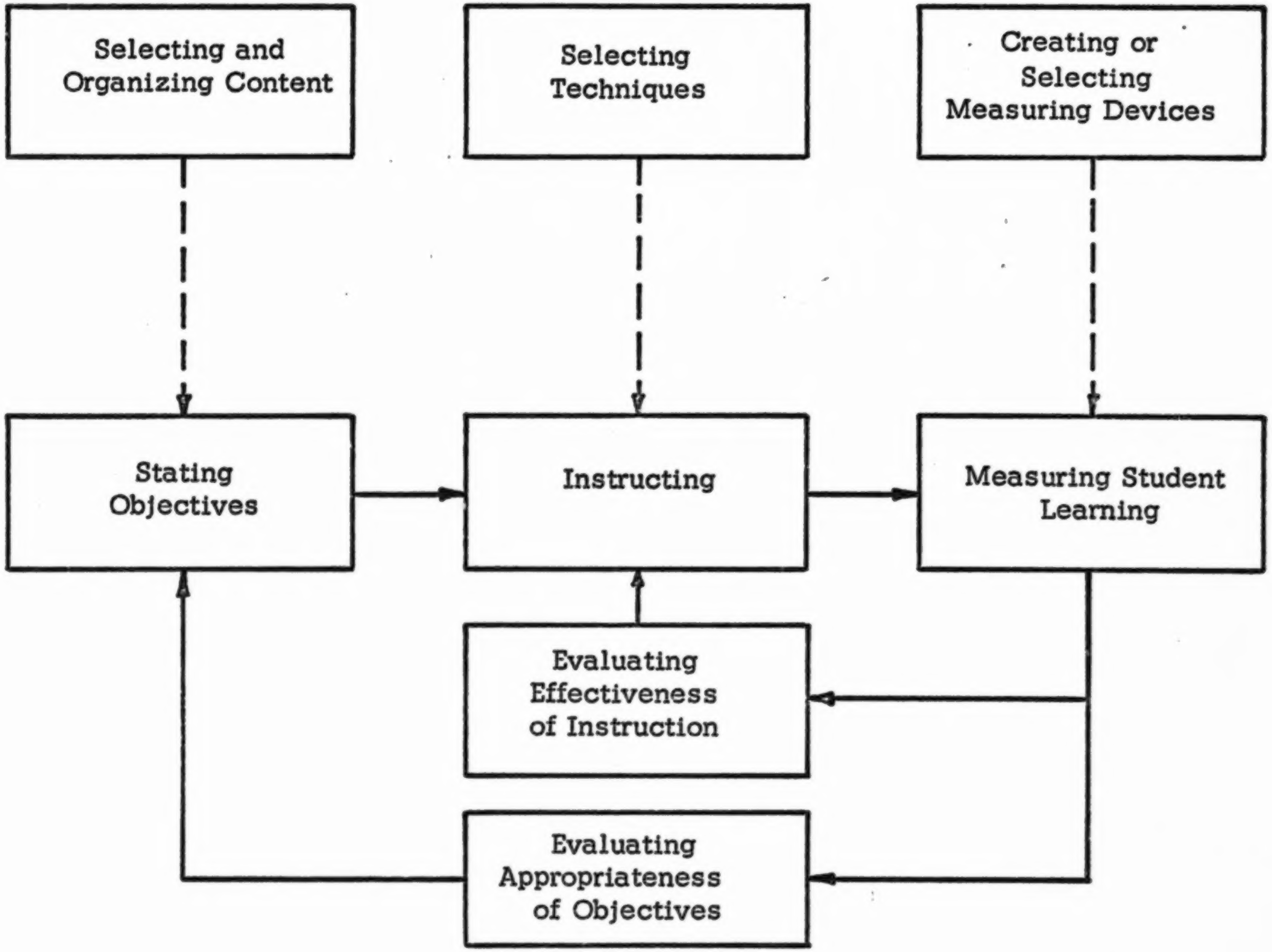
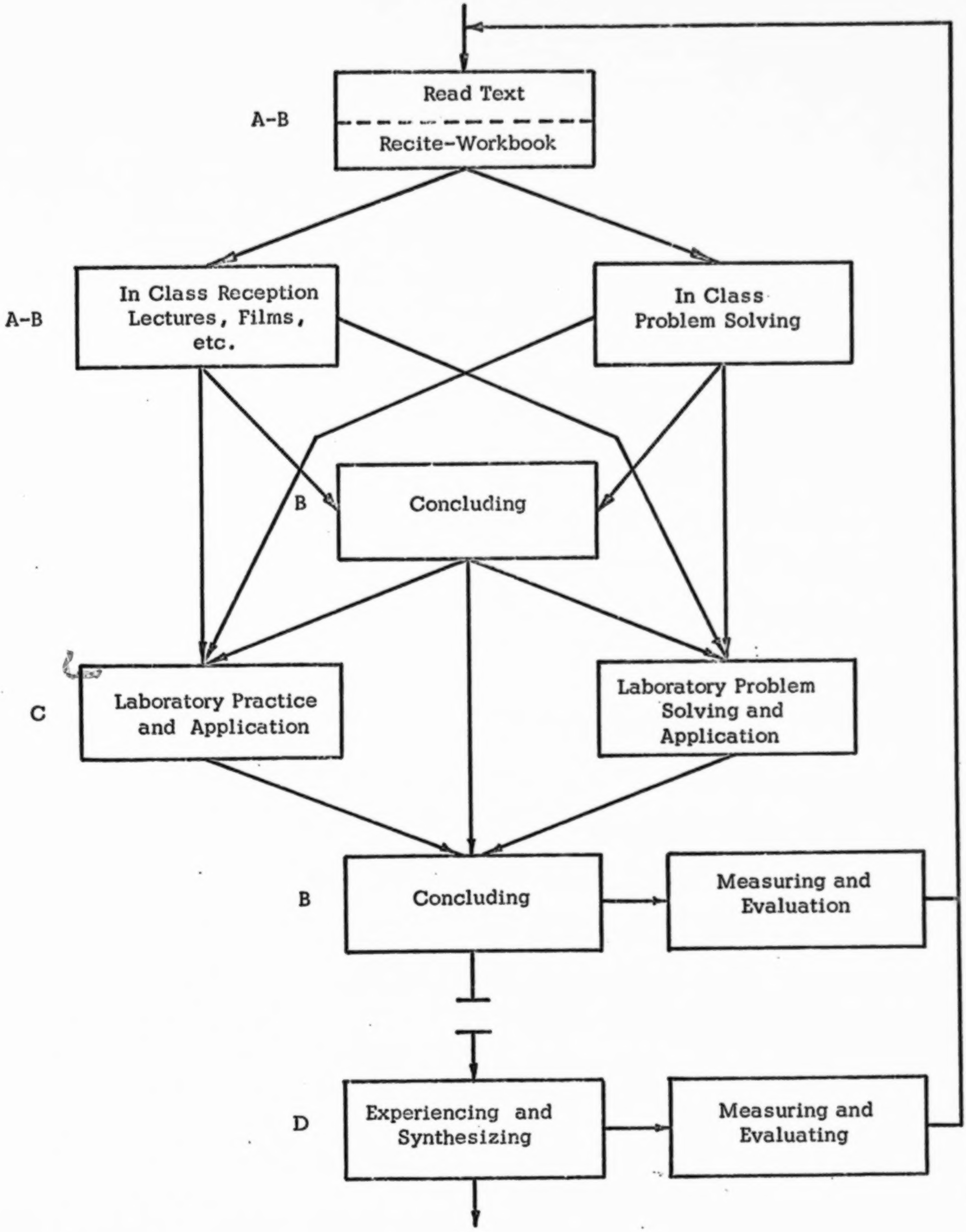

Selecting and Organizing Content
Selecting Techniques
Creating or Selecting Measuring Devices
Stating Objectives
Instructing
Measuring Student Learning
Evaluating Effectiveness of Instruction
Evaluating Appropriateness of Objectives

Figure XXXV

INSTRUCTIONAL MODEL


A-B
Read Text
Recite-Workbook
A-B
In Class Reception Lectures, Films, etc.
In Class Problem Solving
B
Concluding
C
Laboratory Practice and Application
Laboratory Problem Solving and Application
B
Concluding
Measuring and Evaluation
D
Experiencing and Synthesizing
Measuring and Evaluating

3. Generalization - Identifying structural similarities to other things
4. Abstraction - Identifying qualities and dealing with qualities apart from the objects in which they are found

Memorize symbols

C Try out

1. Concepts - Application
2. Skills - Practice

D Experience and synthesis

1. Synthesis - Produce new combinations
2. Evaluation and problem solving - Testing and developing hypotheses

(Woodruff, 1961, p. 92)

The above models and processes represent the hypotheses that have been generated by the staff of the Industrial Arts Curriculum Project to describe the way that objectives can best be met. The next section of this paper will present generalizations and ideas from learning theory that lend support to these hypotheses.

Generalizations From Learning Theory. In the search for guidelines or criteria for selection of learning experiences, the question of "how best to teach?" is central. Bugelski (1964, p. 12) states that hardly a single educational practice has an adequate foundation in scientific observations. Educational practice must attempt to solve problems with minimal risk of failure on the basis of present ideas that have sometimes proven themselves to be successful.

However, certain findings from scientists in the field of learning psychology must be relevant to the task of answering the question "how best to teach?" Many educators are aware that researchers in learning theory have not been very interested in curricular problems of professional education. Hill (1963, p. 495) has stated that many learning theorists promote a rather discouraging view of the applicability of the psychology of learning to the problems of education. There is reluctance on the part of learning theorists to suggest any applications of their ideas as stated above. However, Hilgard (1964, p. 403) comments that technology (instructional theory) should utilize suggestions. Technology (instructional theory) must respect learning theory in that it should not violate established principles, but learning theory does not dictate instructional theory directly. Learning theory is likely to help instructional theory by suggesting directions in which answers may be sought, thus saving wasteful empirical search (Hilgard, 1964, p. 404). To throw away learning theory and its evidence is like returning medical practice to the prescientific physician because we value his bedside manner.

Over-all Strategy Guidelines

This section will utilize learning theory whenever possible to document suggestions. However, some hypotheses or hints will be made that have only a limited theoretical background. Much research can be reduced to general contributions concerning: 1) meaningfulness, 2) interference, 3) reinforcement, and 4) readiness. Generalizations from learning theory can seem vague in spite of the amount of evidence available.

Organize Teaching-Learning Material for Meaningfulness. Many writers have made distinctions between nonsense and meaningful materials. In a way, this is a direct support of many curriculum projects. A teacher may understand his subject matter, but he may not know his subject matter as it may or should be organized for efficient learning by persons unacquainted with the subject. A review by Hill (1964, p. 447) of many learning contributions led to the conclusion that the majority of writers seem to agree that the organization of materials as they are presented to learners is the most significant variable in learning. Hill (1964, p. 448) suggests that teachers should use whatever devices needed to make tasks become more meaningful. Special labels within an organizational plan may help. However, meaningfulness can be confused with student understanding. A feeling of understanding is not always needed. Bugelski (1964, p. 204) remarks that understanding tends to do nothing but contribute a feeling of satisfaction about what has been learned. This feeling of understanding can mislead a student to be satisfied even when he has little or no learning. Hull's continuity hypothesis (Hull, 1943) should be relevant. According to this hypothesis, learning is continuous and cumulative. Learning occurs even when it is not observable. It may be weak in terms of other actions that are overtly expressed. Such continuity builds readiness for further learning. With enough attention, almost any student can learn. The point is to make the process as efficient as possible.

Manage Interference. Learning and forgetting are very much associated with the concept of interference. Accordingly, we learn or forget in relation to a competitive situation within ourselves regarding the materials at hand. Teachers are somewhat like cheerleaders in that they encourage students to do what is suggested in competition with other activity. Ausubel's recent book on learning (1963) devotes major attention to ideas about interference. He believes that most learning and its retention are connected to effects of proactive interference. That is, unless new materials to be learned are related in some meaningful way to old ideas, the old ideas will be more competitive and may reduce the effectiveness of new learning activity. Ausubel (1963, p. 24) believes that a structure of meaningfulness (subsumption process) should be arranged whereby major or broad ideas should be developed first and associated with older (known) ideas. As we learn, we tend to go from general ideas to more and more specific ones. Also, units perceived as logical wholes are more meaningful. With logical wholes, Guthrie's (1952) principle of postremity might be added. That is, one should arrange learning units so they can be completed within a learning period. Students should be required to do an activity until they do it correctly. Then, the student should be allowed to practice the correct responses before leaving.

Utilize Reinforcement. Psychologists have long debated whether reinforcement or association (contiguity) explains learning. Reinforcement is defined here as anything that influences learning particular activity in competition with other activity. It may be reward or punishment. It seems that whether or not reinforcement is the total theoretical answer for learning is unimportant for instructional technology. Reinforcement does work. Reinforcement needs to be studied for particular uses by curricular areas. Mere knowledge of results may be all that is necessary in one case, an extrinsic reward may be needed in another case. Bugelski (1964) implies that extrinsic rewards should be advocated in order to help develop intrinsic rewards. The acceptance of intrinsic rewards is itself learned. Success is well known for being the father of future success. Thus, when in doubt, reward behavior. B. F. Skinner has advocated in many of his writings that reward should always be preferred over punishment. Although punishment may produce some desired results, it tends to possess undesirable side-effects.

Bugelski (1964, p. 120) suggests that punishment can be valuable if there is an immediate opportunity for students to learn correct behavior that will be rewarded. In this sense, punishment may make the rewards seem more pleasant.

Manage Conditions for Transfer and Readiness. The development of insights by learners often ranks highly among goals for learning; however, there is controversy regarding procedures that ought to be taken for its enhancement. Insight is an organization of ideas that must come from within learners. Insight explains what seems to happen when it appears that a learner understands a relationship.

Although it appears that insights just occur or do not occur, Bugelski (1964, p. 204) thinks that positive steps should be made to "set the stage" for insight. He considers that teachers should lead students to perceive relationships by almost any technique available. He doubts whether it is necessary to require students to "dig it out for themselves." In this regard, learners should have an expectancy that is positive toward a desired goal. This provides a beneficial condition of psychological set.

Ausubel has studied student readiness for learning and advocates that although young children need perceptual experiences in the sense of "learning by discovery," students of junior-high school age can learn to acquire new concepts by more direct and efficient reception learning (1963, p. 19) is one of Ausubel's expressions that relates to the meaningful organization of ideas for teaching.

D. O. Hebb (1949) has influenced recent thinking about insight and readiness by his concern for the A/S ratio. Hebb's research has demonstrated that lower animals and small children are dominated by sensory (of the A/S) areas of the brain. Thus, such learning requires direct stimuli. However, with increasing age, the association areas (of the A/S) of man's brain become dominant. Then, learning benefits from mediation. (In fact, association cannot be avoided). A young person's learning is characterized by Hebb as being a series of S-R connections. Later, various associations might go between S and R connections.

An example might be the small child who has difficulty in learning each word (S-R). Later, he can listen to words used only once in various combinations in sentences and remember then with little difficulty. Early learners are slow because of their building work with tools. Later, the tools may be used in many varied patterns (through association) as may serve a purpose.

Young students seem to have an advantage over older learners in learning basic sensory connections because they are less bothered by associations from previous learning that may cause interference.

Specific Activity Guidelines

The teaching model or the model of the instructional process that will be used by the Industrial Arts Curriculum Project has been structured, in part, from evidence presented in this section. The general order of the teaching day (unit of instruction) involves: 1) textbook reading, 2) answering workbook-text questions, 3) classroom presentation (various means), 4) student laboratory activity, and 5) review and evaluation.

Textbooks. A major task of a textbook is to present ideas in a meaningful way. Ausubel's writings tend to imply that textbooks should be written in a fashion whereby there is an overview of each topic in connection with related topics that may be understood by the learner. The development of the textbook might be compared to a widening circle around an object dropped in water. Programed instructional aids have helped to distinguish between a (teaching) textbook and a reference book (like a dictionary). Textbooks should allow the student to be independent of the teacher. (The teacher is needed for help in applying the knowledge.) Carefully prepared materials benefit from study questions imposed with the materials along with self-quizzes. This provides feedback which assures the student that he is learning what is intended.

Workbook-text Questions. Workbooks are very effective inasmuch as attention is subject to control. Since various researchers consider that there is no escape from some drill work involving rote memory, drill work can be managed rather easily with workbooks. Many ideas can be learned best by posing questions that act as problems to be solved. For such activities, it is often desirable to supply correct answers with "prompts" as are used with programed texts. Later, as students develop in a given area, it is probably advisable to have answers then made available only after some initial effort has been made by students. Students should be encouraged to answer questions on their own, without the benefit of "prompts," as instruction progresses. After continued success with materials, students might learn to enjoy workbook questions as they enjoy puzzles or games.

Class Presentations of Topics. Three selected means for classroom presentation are lectures, pupil-teacher interaction through discussion, and various instructional media, e.g., films, charts, and programed instruction.

a) Lectures. McKeachie (1963, p. 17) recommends that lectures be focused around a problem with attempts to solve the problem within the period. Straight materials for knowledge can be presented in books.

b) Discussion. As lectures have been presented here, they are similar to a discussion in which one person does all the speaking. Actual discussions allow the instructor to be assured that he is approaching topics in ways meaningful to students. Discussions break down if students have not had the appropriate background experience or knowledge to discuss problems in such a way to receive instructor feedback. A recent article by Hilgard (1965) has reinforced viewpoints by Mowrer (1960) and Bugelski (1964) that teachers have a basic responsibility to influence the emotional environment for learning. That is, to stimulate interest in the subject that leads to hope rather than fear. The teacher must try to get students to enjoy working with the ideas or materials involved. Certainly, one big difference between work and play is emotional reaction. The teacher may lead his students to arrive at conclusions that arouse a sense of accomplishment. The teacher, also, can express appreciation of how well the students are learning.

c) Film and Television. McKeachie (1963, p. 73) remarks that any automated material should be able to teach particular objectives well. Devices such as television allow simulated field trips or enlarged details of an operation that may be otherwise unavailable. Imagination for ideas and quality production are the essential components.

> Neal Miller (1957, p. 38) has been concerned with motivational aspects of television and films. He says that there is a need to combat an entertainment set that is prevalent because of the ubiquitous use of motion pictures and television for mass entertainment. Miller suggests that films should have tests built into their presentation or else tests should be given immediately after films are presented. Students must expect to be learning.

Laboratory Activity. Any laboratory activity that provides the opportunity for students to work on problems tends to allow feelings of reward to be achieved. It is important that tasks be graded so the likelihood of success is enhanced. Depending upon the objectives involved, there often is as much value in guiding students to make discoveries as to allow them to learn things by themselves. This is a question of experience with particular students with a particular curriculum that is organized. Lumsdaine (1961) found that demonstrations in laboratories need to be examined in terms of the sequence length that a learner can assimilate. He should learn enough so he can practice what is learned with little or no error before leaving the laboratory.

Review and Evaluation. Learning theory and measurement theory need to be integrated. In general, it seems that any review is benefitted by allowing students to pose questions that might be solved with little teacher guidance. Transfer of the use of ideas to new situations is aided by opportunities to work in new situations under some direction. An important issue in review work is to help students do well. Students should be encouraged to recognize what they have learned rather than to be ridiculed for mistakes. B. F. Skinner believes that students should be prevented from making any more errors than necessary. Situations ought to be graded so that difficult tasks can be handled by the time a student is ready to tackle them. Bugelski (1964, p. 256) refers to many current secret methods involving tests as the "educational mystique." He thinks that its lasting benefits are questionable. It's almost like not allowing athletes in team sports to prepare directly for meeting particular opponents.

Program Density. The daily sequence of textbook reading, workbook questions, classroom presentation, student activity, and review and evaluation will provide a controlled "program" for the course. This programing is not as totally controlled and rigid as a programed textbook or a teaching machine program, but it has similar elements.

Green (1962) centers major attention on one variable called program density. Program density refers only to the rate that new ideas are being introduced. Students differ in how they can tolerate or benefit from high amounts of density. Experience with particular materials allows one to predict student success. Green advocates the preparation of materials that are divided into units (programed instruction) that are pretested before distributed to large groups. In a sense, one major potential advantage to programed material is that it is analyzed for meaningfulness according to demonstrated student success. Green hints that it is like having a critical book review before one's book is distributed.

Summary. The selection of learning experiences and the identification of guidelines for the development of teaching-learning materials are influenced by several factors included within the categories of teacher characteristics, instructional theory, and learning theory.

The factors of knowledge of subject matter, values, concept of self, and methodological skill were recognized as significant teacher variables. Keeping the "average" industrial arts teacher in mind, these factors will affect program decisions.

The need for the development of a theory of instruction was discussed, and a model of instruction that will be used by the Industrial Arts Curriculum Project was presented.

Selected findings from learning theory were cited in support of the over-all strategy of materials development and specific activities in the instructional model. The most relevant generalizations from learning theory were represented within the categories of meaningfulness, interference, reinforcement, and readiness.

MEASUREMENT AND EVALUATION

The final factor affecting the selection of learning activities is that of evaluation. The major concern should be that evaluation not be a terminal process, but that it provide feedback that aids in improving various aspects of the program. Evaluation should not end with the statement that "a good (or poor) job was done."

In the context of this discussion, the word "measurement" will stand for the mechanical aspect of data collection and summarization, while the word "evaluation" will be used for the process of interpreting the data and attaching value to certain interpretations.

There are three major phases that should be established in an evaluation program. Measurement should occur within each of these phases. The phases are as follows: 1) measurement of behavior change or goal attainment, 2) evaluation of the effectiveness of instructional procedures, and 3) evaluation of the appropriateness of objectives.

Figures XXXIV and XXXV on pages 287 and 288contain these phases. An examination of these figures shows that feedback loops are present, and it is basically through a feedback process that evaluation should affect selection of learning activities. However, there is another way that evaluation affects this selection. In the process of stating objectives in terms of student behavior or human performance, conditions under which the learning will be demonstrated and measured should be carefully delineated.

Mager has stated it the following way:

> Regardless of how you choose to present it, your statement of objective will define the behavior more sharply if it contains words describing the situation (givens, allowances, restrictions) under which the student will be expected to show his achievement of the objective (Mager, 1962, p. 33).

The situation that is stated or given will illustrate, many times, an effective way of teaching for the objective, or will outline the conditions under which learning should occur. This was discussed more fully on pages 246 to 253 of this chapter.

Measurement of Behavior Change. Since learning is a change in behavior, one measures behavior to find out if the desired learning occurred, or if objectives were met. Three uses can be made of the data collected when measurement of learning is carried out. Figure XXXVI illustrates these uses.

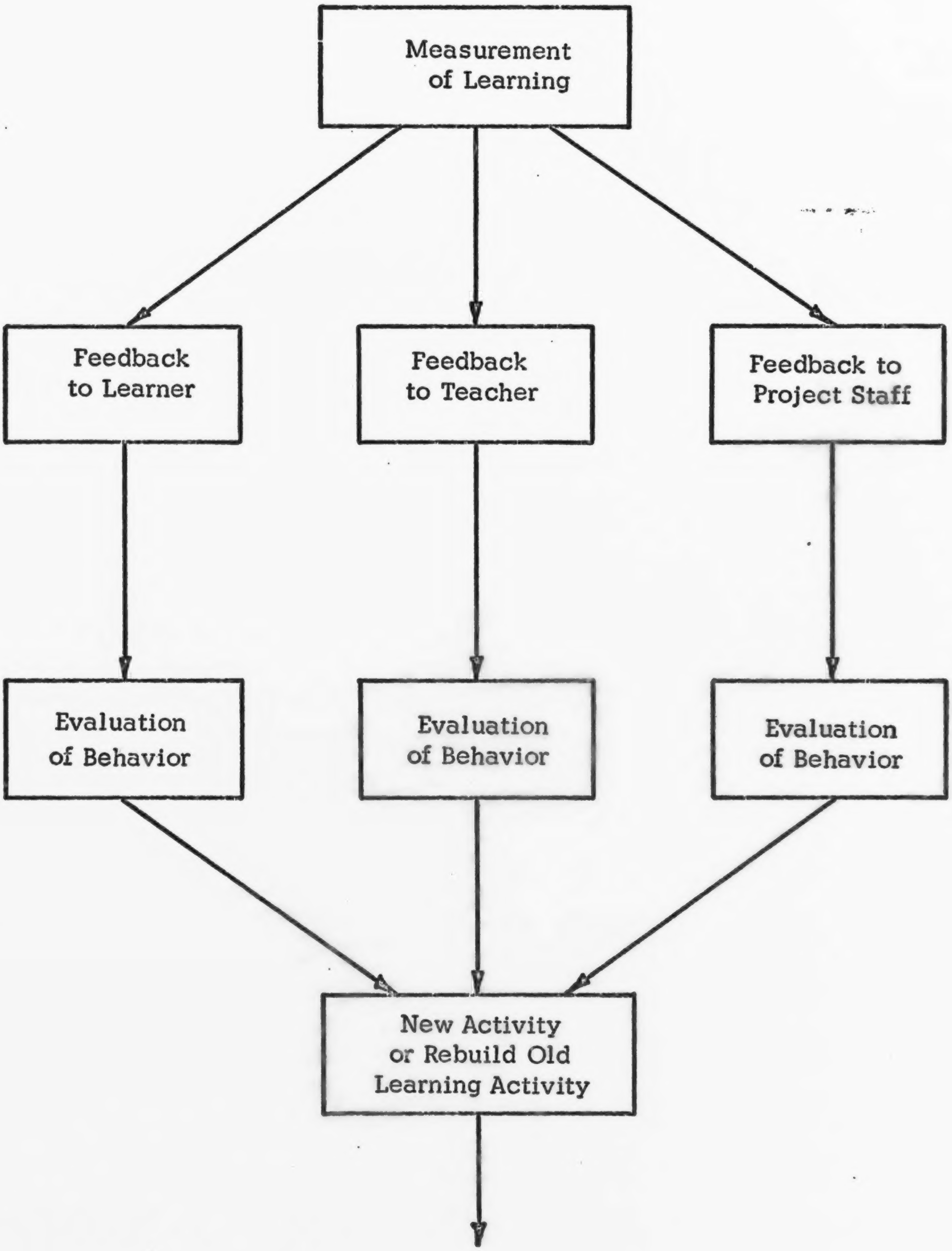
The first use of this information is made by the learner who makes judgments as to the appropriateness of his previous behavior. He is reinforced for correct behavior, and advised about which of his behaviors are in need of correction. This information is internalized, and he enters the next learning situation with a set that has been effected by this feedback.

The second use of this information gained by the measurement of learning is made by the teacher. The process here is similar to that carried on by the learner. The teacher receives the information, makes a judgment as to the appropriateness of his behavior, and is either reinforced, or else becomes aware of the fact that his teaching behavior was not satisfactory. Based on this judgment, he enters the new learning situation and behaves accordingly.

The third use of the data is made by the Project staff and this use takes two forms. The first use is to make additional value judgments concerning the appropriateness of various instructional procedures and the appropriateness of the objectives themselves, and to make recommendations for the next time this objective is implemented. Initial value judgments were made during syllabus development. The second use made by the staff is to judge the effectiveness of procedures and techniques and to use these judgments when considering the next and subsequent objectives.

Figure XXXVI

EVALUATION LOOP AND USE OF MEASUREMENT DATA


Measurement of Learning
Feedback to Learner
Feedback to Teacher
Feedback to Project Staff
Evaluation of Behavior
Evaluation of Behavior
Evaluation of Behavior
New Activity or Rebuild Old Learning Activity

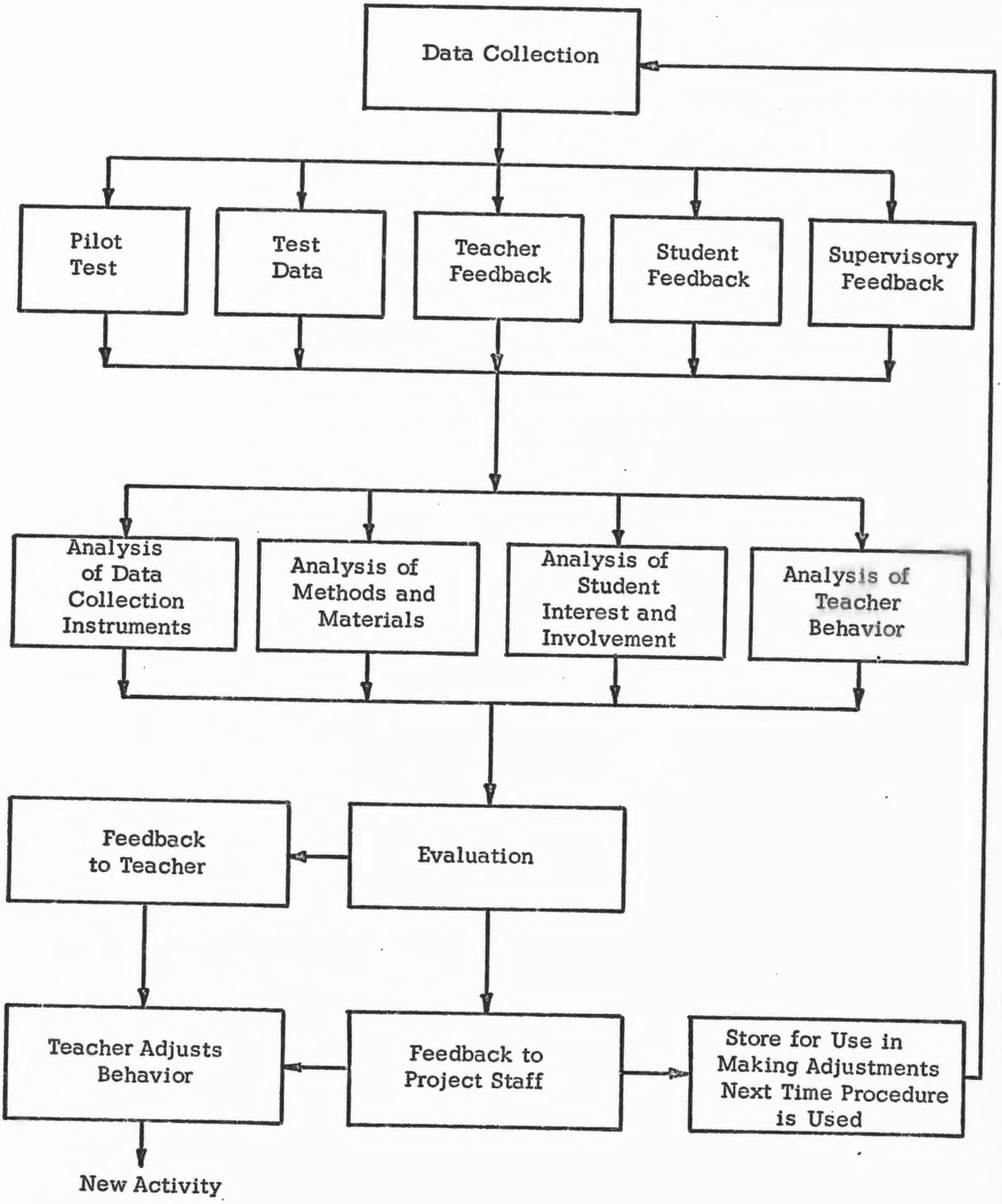
Evaluation of the Effectiveness of Instructional Procedures. This phase is illustrated in part by the rectangle in Figure XXXVI, dealing with the Project staff. Figure XXXVII more fully represents the process followed when instructional procedures are evaluated. There are five primary sources or kinds of data: 1) data from the field or pilot test of a procedure, 2) test data that measure if the objective was met, 3) teacher data that reflect teacher reaction and recommendations, 4) student data that reflect student feedback as to their level of interest and involvement, and 5) supervisory data that is feedback from supervisors, administrators and Project staff members who work closely with teachers and observe the use of various procedures.

Four types of analysis of the above data take place. These are 1) a check on the validity, reliability and useability of data-gathering instruments, 2) an analysis of the appropriateness of methods and materials for a particular objective, 3) an assessment of observed and felt student interest and involvement, and 4) analysis of teacher behavior to see if the teacher actually used behaviors that were intended to be used with different methods or activities.

An evaluation of the appropriateness of the activity for a particular objective is then made and disseminated to the teacher who adjusts his behavior and to the Project staff which stores the information and makes recommendations for the next time this procedure is used. The Project staff can then advise the teacher how he can alter his behavior.

Figure XXXVII

EVALUATION OF PROCEDURES


Data Collection
Pilot Test
Test Data
Teacher Feedback
Student Feedback
Supervisory Feedback
Analysis of Data Collection Instruments
Analysis of Methods and Materials
Analysis of Student Interest and Involvement
Analysis of Teacher Behavior
Feedback to Teacher
Evaluation
Teacher Adjusts Behavior
Feedback to Project Staff
Store for Use in Making Adjustments Next Time Procedure is Used
New Activity

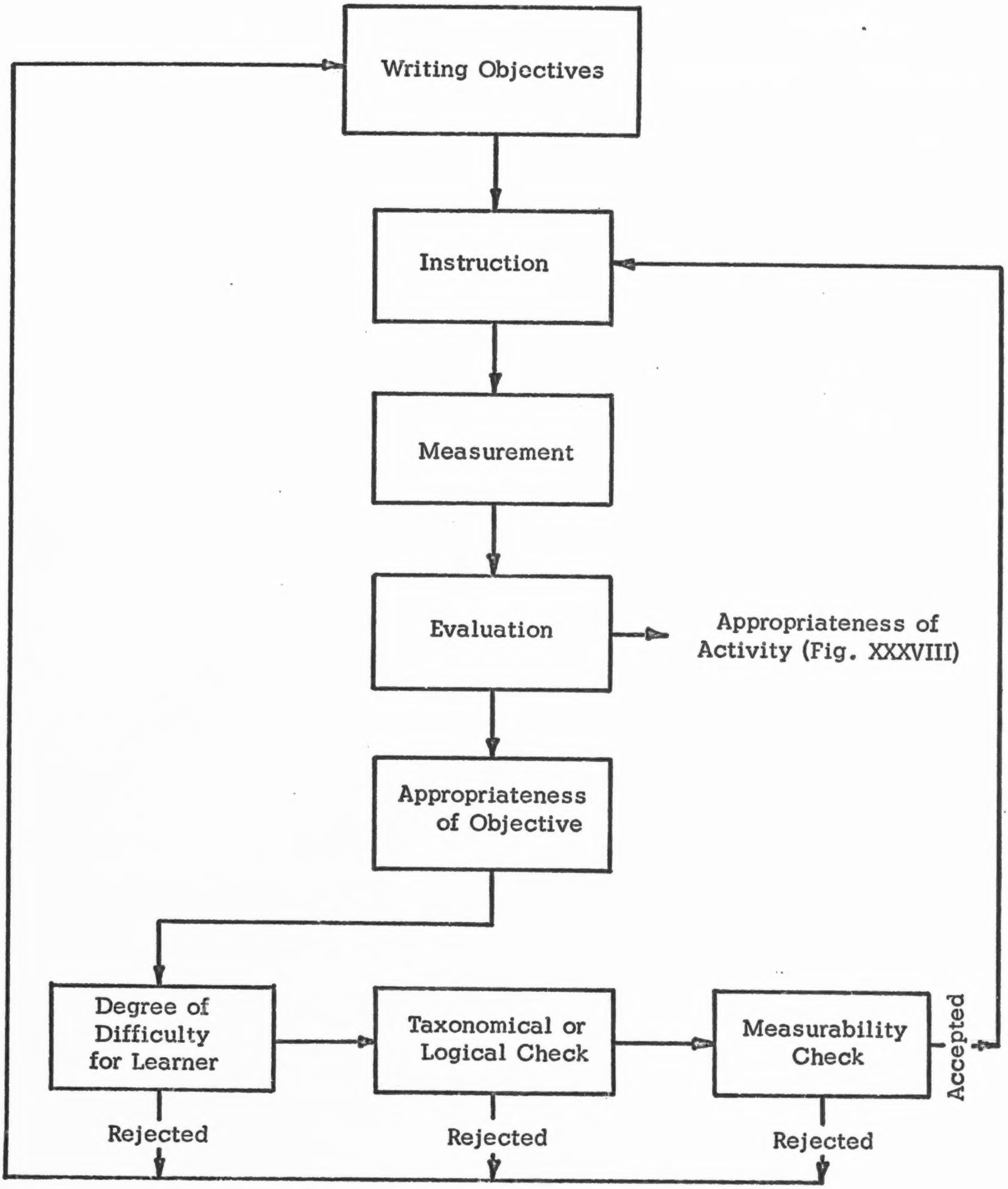
Evaluation of the Appropriateness of Objectives. The next step is to make a judgment as to whether or not objectives were appropriate. As is seen in Figure XXXVIII, this first involves asking questions as to the degree of difficulty for the learners involved. Secondly it involves a check as to whether this objective was sound in terms of its relation to higher-level objectives (level here referring to levels in the several taxonomies of educational objectives) and whether it was logical in terms of the subject matter, skill, or behavior it stood for. The third question is a judgment as to its measureability. Was it possible to test for this particular object through valid test items, or was the behavior so vague that validity can only be hoped for and not demonstrated through replication of a specific behavior?

After these checks are made, and at various stages in these checks, decisions are made to accept or reject an objective. If the objective is accepted at each checkpoint, it is put to the next test. If the objective is rejected, an analysis of the reason(s) for rejection is made and it is rewritten and reinstated into the Project.

Summary. A major purpose of evaluation is to enable Project staff members and teachers to make judgments based on a rational process as to the success of an instructional program and to provide information that aids in building a better program. A system to evaluate objectives, instruction, and activities was proposed.

Figure XXXVIII

EVALUATION OF APPROPRIATENESS OF OBJECTIVES


Writing Objectives
Instruction
Measurement
Evaluation
Appropriateness of Activity (Fig. XXXVIII)
Appropriateness of Objective
Degree of Difficulty for Learner
Taxonomical or Logical Check
Measurability Check
Accepted
Rejected
Rejected
Rejected

Behavior change or goal attainment should be assessed. The effectiveness of instructional procedures should be determined. A judgment regarding the appropriateness of objectives should be made. Through a feedback process, learning activities can be accepted, modified, or rejected.

CONCLUDING STATEMENT

This rationale for the selection and organization of learning experiences and the development of course materials of the Industrial Arts Curriculum Project has taken into account six general factors or elements. These factors are: 1) the structure of the body of knowledge, 2) objectives of instruction, 3) the nature of the learner, 4) school facilities and materials, 5) instructional procedures and materials, and 6) measurement and evaluation. Operational guidelines were not developed in each instance. An attempt was made to make explicit the processes by which the staff made decisions concerning these various factors. In many cases, the process was judgmental, and it was based on what the staff believed was sound educational practice. In other cases it was possible to document the process by referring to acknowledged leaders in the field and to research findings. By building this rationale, the staff believes it has accomplished what relatively few other curriculum reform projects have been able to do--to provide the opportunity for those who are not connected with the Project to examine and pass judgment on the processes followed by the Project staff in making instructional design decisions.

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Appendix A

ELEMENTS OF THE LIBRARY SEARCH FOR "TECHNOLOGY"

Elements of the library search for "technology," its definitions structure, divisions, descriptions and nature.

Library of Congress Catalog, Books: Subjects. Ann Arbor, Michigan: J. W. Edwards, Publisher, Incorporated.

From 1950 to the latest supplement, April - June, 1965, all publications listed in the English language under the heading "Technology."

Sing, Minnie A. (ed.), *Education Index.* New York: The H. W. Wilson Company.

All publications listed under the two headings of "Technology", "Industry", "Industrial Management" and "Business Management."

Reader's Guide to Periodic Literature. New York: The H. W. Wilson Company

All information on the following headings from March, 1961, to February, 1964. Also supplement published February 10, 1965.

Enployees Training
Vocational Education
Industrial Education
Structure of
Technology
Libraries - Technology and Technical Processes
Technical
Curriculum
Industry
Organization of/for
Principle of
Theory of
Organization
Industrial Management
Administration
Factory
Industrial Organization
Industrial Areas Foundation
Industrial Arts

Technicians in Industry
Education

Appendix B

STANDARD COMMODITY INDEX CLASSIFICATION

Standard Commodity Index Classification, U. S. Technical Committee on Standard Commodity Classification, Washington, 1943.

First Order Classes

I. Crude Materials

II. Basic Materials and Products

III. End Products

First and Second Order Classes

I. Crude Materials

1. Live animals
2. Crude animal products, edible
3. Crude animal products, inedible, except fibers
4. Crude vegetable products, edible
5. Crude vegetable products, inedible, except fibers
6. Fibers, vegetable and animal, unmanufactured
7. Coal, crude petroleum and related crude hydrocarbons
8. Metallic ores, concentrates and their unrefined metallic products
9. Crude non-metallic minerals, except coal and petroleum

II. Basic Materials and Products

1. Leather
2. Boot and shoe cut stock and shoe findings
3. Wood basic materials, except pulpwood
4. Pulp, paper, and paperboard
5. Textile basic manufactures
6. Food and beverage basic materials
7. Oils, fats, waxes, and derivatives, animal and vegetable
8. Petroleum and coal products, except raw materials for chemical industries
9. Chemicals
10. Iron and iron and steel scrap
11. Steel
12. Ferro and non ferrous additive alloys
13. Nonferrous Metals
14. Fabricated metals basic products
15. Nonmetallic mineral basic products - chiefly structural
16. Nonmetallic mineral basic products - chiefly nonstructural

Appendix B cont'd.

17. Miscellaneous basic materials

III. End Products

1. General purpose industrial Machinery and Equipment
2. Electrical Machinery and Apparatus
3. Special Industry Machinery (Machinery for selected Industries requiring specialized Machines)
4. Metal working Machinery
5. Agricultural Machinery and Implements, except Tractors
6. Construction, mining, excavating and related Machinery
7. Tractors
8. Office Machines
9. Miscellaneous Machinery
10. Communication Equipment and Electronic Devices
11. Aircraft
12. Ships, small Watercraft, and marine propulsion Machinery
13. Railroad transportation Equipment
14. Motor Vehicles
15. Miscellaneous transportation Equipment
16. Plumbing and heating Equipment
17. Air-conditioning and refrigeration Equipment
18. Lighting Fixtures
19. Furniture and Fixtures
20. Photographic Goods and processed Motion Pictures
21. Optical Instruments and Apparatus
22. Indicating, recording and controlling Instruments and Accessories, except Watches and Clocks
23. Professional and scientific Instruments and Apparatus, except indicating, recording, and controlling
24. Miscellaneous Equipment
25. Food, manufactured
26. Feed, manufactured
27. Beverages and Ice
28. Tobacco Manufactures
29. Drugs and Medicines
30. Toiletries, Cosmetics, Soap and Household Chemical Preparations
31. Footwear
32. Apparel, except Footwear
33. Fabricated Textile Products, except Apparel
34. End Products of Leather, except Apparel, Footwear and Luggage

Appendix B cont'd.

35. Converted paper Products and pulp Goods
36. Products of Printing and Publishing Industries
37. Rubber end Products, natural and synthetic, except Footwear and Clothing
38. End Products of metal Industries, except Machinery and Equipment
39. Finished wood products, except Furniture and Millwork
40. End Products of Glass, Clay and Stone
41. Miscellaneous End Products of Manufacturing Industries
42. Small Arms and Components
43. Artillery, naval Guns, Mortars, and Components
44. Small arms Ammunition and specifically adapted Components
45. Artillery, Naval, and mortar Ammunition and specifically adapted Components
46. Aerial Bombs and specifically adapted Components
47. Miscellaneous Ammunition and related Products
48. Common Components of Ammunition
49. Fire Control Equipment
50. Miscellaneous Ordnance and Ordnance Material

SOURCE INFORMATION

1. Purpose of Standard Commodity Index Classification: To meet the need for standardization in classification.

2. Tentative draft issued in 1942.

3. Technical Committee considered comments received from various federal agencies and commodity experts in government and industry.

4. Final Report Issued in January, 1943.

5. Vol. I presents complete structure of the Standard Commodity Index Classification

6. Vol. II presents an alphabetical index of the items included in Vol.I.

Appendix C

ENTERPRISE STATISTICS

Enterprise Statistics: 1958, Part 3, Link of Census Establishment and Internal Revenue Service Corporation Data. Based on the 1958 Censuses of Business, Manufactures, and Mineral Industries and the Internal Revenue Service "Statistics of Income, 1958-59."

Murray D. Dessel, Coordinator
U. S. Department of Commerce
Bureau of the Census, U. S. Government Printing Office,
Washington, D. C., 1964

I. Mineral Industries

1. Metal Mining
2. Bituminous Coal and Lignite Mining
3. Crude Petroleum and Natural Gas
4. Nonmetallic Mineral and Anthracite Mining

II. Manufacturing

1. Beverages
2. Food and Kindred Products
3. Tobacco Manufactures
4. Textile - Mill Products
5. Apparel and other finished Products made from Fabrics
6. Lumber and wood Products, except Furniture
7. Furniture and Fixtures
8. Paper and allied Products
9. Printing, publishing, and allied Industries
10. Chemicals and allied Products
11. Petroleum refining and related Industries
12. Rubber and Plastics Products
13. Leather and Leather Products; converters
14. Stone, Clay and Glass Products
15. Primary Metal Industries
16. Fabricated metal Products, except Machinery and Transportation Equipment
17. Machinery except Transportation Equipment and Electrical
18. Electrical Machinery and Equipment
19. Transportation Equipment, except Electrical and Motor Vehicle Equipment
20. Motor Vehicle and Equipment, except Electrical

Appendix C cont'd.

21. Scientific Instruments, Photographic Equipment, Watches, Clocks
22. Miscellaneous Manufacturing
23. Manufacturing not allocable to IRS Groups 19-40

III. Wholesale Trade

1. Food and related Products Wholesalers
2. Electrical Goods, Hardware, and Plumbing Wholesalers
3. Miscellaneous Wholesalers
4. Wholesalers not allocable to IRS Groups 477-498.

IV. Retail Trade

1. Food Stores
2. General Merchandise Retailers
3. Apparel and Accessories Stores
4. Furniture, Homefurnishings, Appliance, Radio, and Music Stores
5. Automotive Dealers and Gasoline Service Stations
6. Eating and Drinking Places
7. Building Materials, Hardware, and Farm Equipment Retailers
8. Other Retail Trade
9. Retail Trade not allocable to IRS Groups 520-608.

V. Wholesale and Retail trade not Allocable

VI. Selected Services

1. Hotels, Camps, and other Lodging Places
2. Personal Services
3. Business Services
4. Automobile and other Repair Services
5. Motion Pictures
6. Amusement and Recreation Services, except Motion Pictures

VII. Other Industries

Appendix D

COMMODITY INDEXES FOR THE STANDARD INTERNATIONAL TRADE CLASSIFICATION, UNITED NATIONS, NEW YORK

Commodity Indexes for the Standard International Trade Classification, United Nations, New York, 1963.

Trade Classifications.

1. Food - Live Animals
2. Beverages and Tobacco
3. Crude Materials, inedible except Fuels
4. Minerals Fuels, Lubricants and Related Materials
5. Animal and Vegetable Oils and Fuels
6. Chemicals
7. Manufactured Goods (classified chiefly by material)
8. Machinery and Transport Equipment
9. Miscellaneous Manufactured Articles
10. Commodities and Transactions Not Classified According to Kind

All the following use the Standard International Trade Classification in reporting:

1. Yearbook of International Trade Statistics, United Nations, 1963.

2. U. S. Exports, Commodity by County, U. S. Department of Commerce, 1964 Annual Report.

3. U. S. Imports of Merchandise for Consumption, U. S. Department of Commerce, 1964 Annual Report.

Appendix E

NATIONAL DIRECTORY OF COMMODITY SPECIFICATIONS

National Directory of Commodity Specifications, U. S. Department of Commerce, Washington, 1945.

Classification System:

1. Animals and Animals Products (except wool and hair)
2. Vegetable Food Products and Beverages
3. Vegetable Products, except Food, Fiber, and Wood
4. Textiles
5. Wood and Paper
6. Nonmetallic Minerals
7. Ores, Metals, and Manufactures (except Machinery, Vehicles, and Electrical Supplies)
8. Machinery and Vehicles
9. Chemicals and Allied Products
10. Commodities not Elsewhere Classified.

SOURCE INFORMATION

1. The 1945 edition is the third.
2. The first edition was published in 1925.
3. It was revised and enlarged in 1932.
4. Listed and briefly described are:
   Standards and specifications of (a) trade organizations, technical societies, and organizations representative of industry, and (b) the federal government.

Appendix F

U.S. PATENT OFFICE CLASSES ARRANGED IN ALPHABETICAL ORDER

CLASS	TITLE
51	Abrading
181	Acoustics
156	Adhesive Bonding and Miscellaneous Chemical Manufacture
226	Advancing Material of Indeterminate-Length
244	Aeronautics
259	Agitating
86	Ammunition and Explosive-Charge Making
102	Ammunition and Explosive Devices
330	Amplifiers
272	Amusement and Exercising Devices
273	Amusement Devices, Games
46	Amusement Devices, Toys
119	Animal Husbandry
2	Apparel
223	Apparel Apparatus
221	Article Dispensing
3	Article Dispensing Members
236	Automatic Temperature and Humidity Regulation
190	Baggage
4	Baths, Closets, Sinks and Spittoons
136	Batteries
5	Beds
6	Bee Culture
8	Bleaching and Dyeing; Fluid Treatment and Chemical Modification of Textiles and Fibers
9	Boats, Buoys and Aquatic Devices
10	Bolt, Nail, Nut, Rivet and Screw Making
281	Books, Strips and Leaves
12	Boot and Shoe Making
36	Boots, Shoes and Leggings
77	Boring and Drilling
175	Boring or Penetrating the Earth
215	Bottles and Jars
188	Brakes
107	Bread, Pastry and Confection making
14	Bridges
300	Brush, Broom and Mop Making
15	Brushing, Scrubbing and General Cleaning
24	Buckles, Buttons, Clasps, Etc.
50	Building Structures
17	Butchering
79	Button Making
40	Card, Picture and Sign Exhibiting
233	Centrifugal-Bowl Separators
59	Chain, Staple and Horseshoe Making
297	Chairs and Seats
194	Check-Controlled Apparatus
23	Chemistry
260	Chemistry, Carbon Compounds
204	Chemistry, Electrical and Wave Energy
195	Chemistry, Fermentation
71	Chemistry, Fertilizers
279	Chucks and Sockets
209	Classifying, Separating and Assorting Solids
134	Cleaning and Liquid Contact with Solids
292	Closure Fasteners
268	Closure-Operators
160	Closures, Partitions and Panels, Flexible and Portable

CLASS	TITLE
11	Books, Making
192	Clutches and Power-Stop Control
118	Coating Apparatus
117	Coating: Processes and Miscellaneous Products
133	Coin Handling
340	Communications, Electrical
343	Communications, Radio Wave
252	Compositions
106	Compositions, Coating or Plastic
7	Compound Tools
159	Concentrating Evaporators
193	Conveyors, Chutes, Skids, Guides and Ways
302	Conveyors, Floid Current
198	Conveyors, Power-Driven
147	Coopering
30	Cutlery
83	Cutting
31	Dairy
329	Demodulators and Detectors
32	Dentistry
232	Deposit and Collection Receptables
222	Dispensing
202	Distillation
85	Driven, Headed and Screw-Threaded Fastenings
34	Drying and Gas or Vapor Contact with Solids
172	Earth Working
35	Education
13	Electric Furnaces
219	Electric Heating
313	Electric Lamp and Discharge Devices
314	Electric Lamp and Discharge Devices, Consumable Electrodes
316	Electric Lamp and Discharge Devices, Manufacture and Repair
150	Cloth, Leather and Rubber Receptables
315	Electric Lamp and Discharge Devices, Systems
339	Electrical Connectors
310	Electrical Generator or Motor Structure
338	Electrical Resistors
307	Electrical Transmission or Interconnection Systems
317	Electricity
320	Electricity, Battery and Condenser Charging and Discharging
200	Electricity, Circuit Makers and Breakers
174	Electricity, Conductors and Insulators
321	Electricity, Conversion Systems
324	Electricity, Measuring and Testing
318	Electricity, Motive Power Systems
322	Electricity, Single Generator Systems
191	Electricity, Transmission to Vehicles
323	Electricity, Voltage Magnitude and Phase Control Systems
187	Elevators
227	Elongated-Member-Driving Apparatus
37	Excavating
92	Expansible Chamber Devices
149	Explosive and Thermic Compositions or Charges
168	Farriery
256	Fences
182	Fire Escapes, Ladders, Scaffolds
169	Fire-Extinguishers
42	Firearms
43	Fishing, Trapping and Vermin Destroying
141	Fluent Material Handling, with Receiver or Receiver Coating Means

Appendix F cont'd.

CLASS	TITLE
99	Foods and Beverages
44	Fuel and Igniting Devices
110	Furnaces
261	Gas and Liquid Contact Apparatus
48	Gas, Heating and Illuminating
230	Gas Pumps and Fans
55	Gas Separation
39	Gates
90	Gear Cutting, Milling and Planing
33	Geometrical Instruments
65	Glass Manufacturing
294	Handling, Hand and Hoist-Line Implements
54	Harness
56	Harvesters
165	Heat Exchange
263	Heating
237	Heating Systems
108	Horizontally Supported Planar Surfaces
58	Horology
61	Hydraulic and Earth Engineering
67	Illuminating Burners
240	Illimination
336	Inductor Devices
123	Internal-Combustion Engines
63	Jewelry
277	Joint Packing
289	Knots and Knot Tying
280	Land Vehicles
278	Land Vehicles, Animal Draft Appliances
296	Land Vehicles, Bodies and Tops
298	Land Vehicles, Dumping
301	Land Vehicles, Wheels and Axles
69	Leather Manufactures
158	Liquid and Gaseous Fuel Burners
122	Liquid Heaters and Vaporizers
137	Fluid Handling
303	Fluid-Pressure Brake and Analogous Systems
239	Fluid Sprinkling, Spraying and Diffusing
210	Liquid Purification or Separation
70	Locks
184	Lubrication
74	Machine Elements and Mechanisms
308	Machine Elements, Bearings and Guides
64	Machine Elements, Shafting and Flexible Shaft Couplings
282	Manifolding
115	Marine Propulsion
214	Material or Article Handling
73	Measuring and Testing
124	Mechanical Guns and Projectors
167	Medicines, Poisons and Cosmetics
72	Metal Deforming
22	Metal Founding
228	Metal Fusion-Bonding Appartus
76	Metal Tools and Implements, Making
148	Metal Treatment
29	Metal Working
189	Metallic Building Structures
220	Metallic Receptacles
266	Metallurgical Apparatus
75	Metallurgy
196	Mineral Oils: Apparatus
208	Mineral Oils: Processes and Products
299	Mining or In Situ Disintegration of Hard Material
328	Miscellaneous Electron
16	Miscellaneous Hardware
325	Modulated Carrier Wave Communication Systems
332	Modulators
180	Motor Vehicles
91	Motors, Expansible Chamber Type
253	Motors, Fluid

Appendix F cont'd.

CLASS	TITLE
170	Motors, Fluid Current
185	Motors, Spring, Weight and Animal Powered
84	Music
163	Needle and Pin Making
176	Nuclear Reactions and Systems
151	Nut and Bolt Locks
88	Optics
351	Optics, Eye Examining, Vision Testing and Correcting
352	Optics, Motion Pictures
89	Ordnance
331	Oscillators
224	Package and Article Carriers
53	Package Making
129	Paper Files and Binders
162	Paper Making and Fiber Liberation
93	Paper Manufactures
229	Paper Receptacles
96	Photographic Chemistry, Processes and Materials
95	Photography
285	Pipe Joints or Couplings
138	Pipes and Tubular Conduits
47	Plant Husbandry
111	Planting Plants
264	Plastic and Non-Metallic Article Shaping or Treating: Processes
25	Plastic Block and Earthenware Apparatus
18	Plastics
243	Pneumatic Dispatch
60	Power Plants
21	Preserving, Disinfecting and Sterilizing
100	Presses
290	Prime-Mover Dynamo Plants

CLASS	TITLE
254	Pushing and Pulling Implements
250	Radiant Energy
213	Railway Draft Appliances
258	Railway Mail Delivery
108	Railway Rolling Stock
246	Railway Switches and Signals
295	Railway Wheels and Axles
104	Railways
238	Railways, Surface Track
346	Recorders
62	Refrigeration
235	Registers
152	Resilient Tires and Wheels
94	Roads and Pavements
287	Rod Joints or Couplings
109	Safes, Bank Protection and Related Devices
275	Scattering-Unloaders
234	Selective Cutting (e.g. Punching)
225	Severing by Tearing or Breaking
112	Sewing
271	Sheet Feeding or Delivering
270	Sheet-Material Associating or Folding
113	Sheet-Metal Ware, Making
114	Ships
116	Signals and Indicators
241	Solid Material Comminution or Disintegration
274	Sound Recording and Reproducing
206	Special Receptacles and Packages
267	Spring Services
120	Stationery
161	Stock Material and Miscellaneous Articles
125	Stone Working
186	Store Service
126	Stoves and Furnaces
127	Sugar, Starch and Carbohydrates
248	Supports

Appendix F cont'd.

CLASS	TITLE
283	Printed Matter
101	Printing
103	Pumps
178	Telegraphy
135	Tents, Canopies, Umbrellas and Canes
28	Textiles, Manufacturing
87	Textiles, Braiding, Netting and Lace
26	Textiles, Cloth Finishing
19	Textiles, Fiber Preparation
68	Textiles, Fluid Treating Apparatus
38	Textiles, Ironing or Smoothing
66	Textiles, Knitting
57	Textiles, Spinning Twisting and Twining
139	Textiles, Weaving
130	Threshing
131	Tobacco
132	Toilet
173	Tool Driving or Impacting
306	Tool-Handle Fastenings
81	Tools
291	Track Sanders
212	Traversing Hoists
334	Tuners
82	Turning
199	Type Casting
276	Type Setting
197	Typewriting Machines
312	Supports, Cabinet Structures
211	Supports, Racks
128	Surgery
171	Unearthing Plants or Buried Objects
251	Valves and Valve Actuation
146	Vegetable and Meat Cutters and Comminutors
293	Vehicle Fenders
98	Ventilation
333	Wave Transmission Lines and Networks
177	Weighing Scales
166	Wells
305	Wheel Substitutes for Land Vehicles
157	Wheelwright Machines
231	Whips and Whip Apparatus
242	Winding and Reeling
245	Wire Fabrics and Structure
140	Wireworking
143	Wood Sawing
142	Wood Turning
20	Wooden Buildings
217	Wooden Receptables
144	Woodworking
145	Woodworking Tools
269	Work Holders

Appendix G

A.S.T.M.E. TECHNICAL DIVISIONS

(A)

ASSEMBLY

The Assembly Technical Division encompasses the dissemination and the practical application of scientific information gained through scholarly inquiry into the theory and principles of producing completed units from their components and utilizing manufacturing equipment and engineering sciences to do so.

(B)

CASTING, MOLDING & METALLURGICAL PROCESSING

The Casting, Molding and Metallurgical Processing Division encompasses the dissemination and the practical application of scientific information gained through scholarly inquiry into the theory and principles of founding and implementing the engineering sciences and equipment in those areas of manufacturing where the shaping of a product depends on some or all of its materials being in a molten or liquid condition.

(C)

ENGINEERING MATERIALS

The Engineering Materials Technical Division encompasses the dissemination and the practical application of scientific information gained through scholarly inquiry into the theory and principles of properties of materials and the scientific investigation into the determination of these properties and their significance in relation to manufacturing engineering.

(D)

FINISHING AND COATING

The Finishing and Coating Technical Division encompasses the dissemination and the practical application of scientific information gained through scholarly inquiry into the theory and principles of those manufacturing techniques and operations utilized in the application of protective, decorative and other coatings to manufactured items in production.

Appendix G con't.

(E)

INSPECTION AND QUALITY CONTROL

The Inspection and Quality Control Technical Division encompasses the dissemination and the practical application of scientific information gained through scholarly inquiry into the theory and principles of those engineering activities related to the operations and computations required to maintain product reliability and compliance with approved specifications and standards.

(F)

MANUFACTURING MANAGEMENT

The Manufacturing Management Technical Division encompasses the dissemination and the practical application of scientific information gained through scholarly inquiry into the theory and practice of organizing scientific principles, capital, personnel and equipment, for the manufacture and distribution of products for which there is a predetermined demand.

(G)

MANUFACTURING SYSTEMS

The Manufacturing Systems Technical Division encompasses the dissemination and the practical application of scientific information gained through scholarly inquiry into the theory and principles of those control techniques integrated into the regulation of manufacturing operations, including the utilization of electronic devices to control machine tools.

(H)

MATERIAL FORMING

The Material Forming Technical Division encompasses the dissemination and the practical application of scientific information gained through scholarly inquiry into the theory and principles of those manufacturing operations employed to form material through the utilization of their plastic properties and their reaction to pressure, such investigations to include the necessary manufacturing equipment as well as the development of powder metallurgy processes.

Appendix G con't.

(I)

MATERIAL REMOVAL

The Material Removal Technical Division encompasses the dissemination and the practical application of scientific information gained through scholarly inquiry into the theory and principles of manufacturing operations having to do with shaping materials by removing calculated segments of said materials through cutting, grinding, milling, electrical discharge, chemical reaction, and other methods.

Appendix H

ARTHUR D. LITTLE, INC., DEFINITIONS OF UNIT OPERATIONS

RECORD SYSTEM UNIT OPERATIONS

1.	Conversion:	The rewriting (translation of information from one form to another, either on a different medium and/or in a different code). Examples: card to magnetic tape, magnetic tape to printer, mark sensing, keypunching.
2.	Arranging:	The physical rearrangement (reorganization) of records, usually to facilitate their processing. Example: sorting
3.	Selection:	The physical choice and withdrawal (extraction) of particular records. Examples: selective sorting, selective card reproducing, selective listing. Searching may be an ingredient of this unit operation.
4.	Merging:	The physical unifying of records including the possible rewriting of them. Searching may be a part of this unit operation. Examples: collating and insertion.
5.	Transmission:	The physical movement of a record from one place to another. Examples: transceiver operation, manual transport of card decks.
6.	Storing:	Putting material in a place from which it can be gotten back when needed.
7.	Editing:	The interpretation, classification and perhaps coding of the information submitted to an information handling system. Example: table look-up to assign a code number to a customer and the products he has ordered.
8.	Processing:	The arithmetic, logical or manipulative operations on information pertaining to the record media or the working data itself. The manipulative suboperation includes indexing (re-organization of data), extracting (the selection of data) and insertion (the placement of data).

9. Controlling: Determination of what processes are to be carried out and supervision of their execution. Example: computer modification of its internally stored program.

10. Transferring: The movement of working data in or out of the system. Examples: read or write magnetic tape, punch or read cards, printing, display.

11. Interpretation: The "intelligent" analysis, evaluation, or construing of information provided by the system itself or its performance. As a result of this activity the system is usually affected at some time through changes in its input information or by external control of its operation.

UNIT OPERATIONS IN THE PROCESS INDUSTRIES

12. Crystallization: The formation of a solid crystalline phase from a liquid phase. Accomplished by cooling, evaporation, or addition of a third component that decreases solubility of the solute.

13. Screening: Separation of mixture of particles of various sizes into two or more portions, each of which is more uniform in size of particle than is the original mixture, by passing the material over surfaces provided with openings of appropriate size. Screening may be either dry or wet.

14. Classification: Separation of entities into two or more relatively homogeneous groups on the basis of specific characteristics (size, color, weight, chemical composition, etc.). In the process industries classification has a specific meaning: separation by differential motion in a static or moving fluid medium. Several subclasses are distinguished; in particular, separation by size is called sizing, and separation by density is called sorting. Elutriation is characterized by upward motion of the fluid at a velocity intermediate between the settling velocities of the fractions to be separated. The fluid may be gaseous--as in winnowing--or liquid.

15. Flotation:	Separation of one solid from another by flotation of one of them at or on the surface of a fluid.
16. Sedimentation:	The separation of a suspension into a supernatant clear fluid and a relatively dense slurry containing a higher concentration of solid. May be either a batch or a continuous process.
17. Filtration:	Separation of a heterogeneous mixture of fluid and particles of solid into a solid phase and a liquid, by passing the mixture through a filtering medium which permits the flow of the fluid but retains the particles of solid.
18. Centrifugation:	The application of centrifugal force to produce gradients or forces greater than those of gravity, for purposes of separation, either by settling or by filtration. Machines of relatively large diameter and relatively slow speed of rotation are known as centrifugals; smaller high speed machines are generally known as centrifuges.
19. Solid-Liquid Extraction:	Transfer of one constituent of a solid phase to a liquid phase (solvent). Common terms are lixiviation, leaching, and washing. Extraction always involves two steps; (1) contact of the solvent with the solid to be treated so as to transfer the soluble constituent (solute) to the solvent, and (2) separation of washing of the solution from the residual solid. Although the complete process may include the separate recovery of the solute and solvent, the recovery operation is distinct--e.g., evaporation or distillation.
20. Liquid-Liquid Extraction:	Transfer of a material dissolved in one liquid phase to a second liquid phase. The second liquid (the solvent) must be insoluble, or nearly insoluble, in the solution to be extracted. Extraction is normally followed by a recovery operation, such as distillation, evaporation, or centrifugation.
21. Vapor-Liquid Transfer:	Separation of individual components by use of the difference in equilibrium composition between liquid and vapor phases. In typical industrial equipment, vapors may bubble through a continuous liquid phase, droplets of liquid may fall through a continuous vapor phase, and extended interface may provide contact between the two phases, or these methods may be used in combination.

	Distillation, absorption, and stripping are particular types of vapor-liquid transfer, but are carried out in the same kinds of equipment, often concurrently, and are governed by the same fundamental relationships. Distillation is the process of driving off vapors from liquids or solids and subsequently condensing the vapors. Absorption usually denotes an operation in which the significant transfer is from the vapor phase to the liquid phase. Stripping is the term applied to an operation in which the significant transfer is from the liquid to the vapor phase.
22. Fractionation:	Differential distillation, resulting in relatively complete separation of two or more components of a volatile substance, accomplished by selection of vapor discharge points with respect to a concentration gradient established in a distillation column.
23. Adsorption:	Generation of contact between a fluid mixture and a solid under such conditions that components of the fluid are selectively held on the surface of the solid, with a resulting change in the composition of the remaining fluid. The principal difference between adsorption and solid-liquid extraction is that extraction involves the transfer of material from the solid to the liquid phase, whereas in adsorption the fluid phase gives up material to the solid phase. Chromatographic adsorption is essentially a counter-current multiple stage transfer between a moving solvent phase and a stationary or moving bed of solid adsorbent. It yields high separations of complex materials, and is now replacing fractionation in some industrial processes.
24. Evaporation:	The concentration of solutions by evaporation of the solvent.
25. Drying:	The removal of relatively small amounts of water from relatively large amounts of solids into a gas or air stream.

Appendix H cont'd.

26.	Peeling:	Separation of two material layers of different composition by the application of shearing or tensile forces to the interface. In general, the removal of an outer covering such as bark or skin, but includes hide splitting.
27.	Combining:	Introduction of two or more different substances into a common space, normally a container or reaction chamber, and normally accompanied by control of the relative amounts of the components.
28.	Mixing:	The intermingling of two or more different substances or phases in such a way as to bring about a spatially homogeneous product, by the application of forces resulting in turbulent motion accompanied by shearing stresses of suitable magnitude.
29.	Working:	The addition of energy to a substance by continued plastic deformation in order to bring about a change of state; kneading, mastication, and mixing may contribute to working as well as to mixing.
30.	Agitation:	The production of irregular disturbances or turbulent motion within a fluid by means of mechanical devices acting on that fluid. Its purpose is to promote extraction, mixing, absorption, heat transfer, chemical reaction, and in some cases mass transfer.
31.	Gas-Liquid Transfer of Heat and Mass:	The transfer of vapor between a liquid phase and a carrier gas phase, either for cooling, humidification, dehumidification, or recovery of the vapor constituent from the carrier gas.
32.	Size Reduction of Solids:	Production of smaller mass units from larger mass units of the same material by fracture of the larger units through the application of compressive or shearing forces; tensile forces may be employed under certain circumstances. For most purposes, this operation is equivalent to crushing, but includes also grinding as in flour milling.

Appendix H cont'd.

33. Curing:	Storage of a substance or mixture under controlled conditions (temperature, pressure, humidity, atmospheric composition, etc.) in order to allow relatively slow processes (polymerization, diffusion, etc.) to reach a desired end state. In this sense the term includes cooking, slow drying, smoking, etc., but does not include the injection of preservatives as in the curing of hams.
34. Heat Transfer-Fluids & Solids:	The transfer of heat, by convection and conduction, between a moving fluid and a solid. The primary instance is the transfer of heat in a boiler or condenser, between a moving turbulent fluid and a clean smooth metal tube.
35. Heat Transfer-Vapors & Liquids:	The transfer of heat accompanied by a change of phase, either by condensation or boiling.
36. Heat Transfer-Radiation:	The transfer of heat by radiation and absorption of electromagnetic energy, mainly in the thermal band but not exclusively so.

MATERIALS HANDLING OPERATIONS

37. Pumping and Compression:	The exertion of work on a fluid with resultant change in pressure at the work face. The technical result may be transport of the fluid, compression, or exhaustion of fluid from a chamber.
38. Lifting and Carrying:	The engagement of material in a transport mechanism and subsequent removal of it to a different place.
39. Fluidized Transport of Solids:	Dynamic suspension and transport of more or less finely divided solids in a moving fluid, depending on macroscopic drag forces rather than Brownian forces for suspension. Fluidized solids would settle rapidly from the fluid at rest.
40. Transport of Fluids by Flow:	Movement of a fluid from one place to another through a conduit; the input to the conduit is at a higher energy level than is the output.

FORMING OPERATIONS

41. Vacuum Deposition:	Boiling a material, usually a metal or a ceramic, in a vacuum, and condensing it as a thin film on a cool surface, sometimes through a mask so that a patterned deposit results.
42. Casting:	Pouring molten material into a mold or die and allowing it to freeze.
43. Pressing and Sintering:	Putting powdered metal or a mixture of powdered metals into a die, and heating under heavy pressure to fuse the material into a solid of the desired shape.
44. Forging:	Heating metal to a plastic state and forming it by hammering with a hammer and anvil as the blacksmith does, or compressing with a succession of dies as in the forging of turbine blades.
45. Rolling:	Compressing material and/or causing it to flow plastically by drawing it through a pair or a series of pairs of rollers which may be flat or contoured cylinders, depending upon the shape alterations to be produced. The operation occurs in metal forming, papermaking, felting, etc.
46. Stamping:	Cutting and bending parts from a laminated strip by sharply stamping the strip between a pair of mating dies.
47. Bending:	Changing the radius of curvature of torsion of a surface or cylinder, as by roll forming or by use of a sheet metal brake. Includes formation of angles.
48. Drawing:	Forming complex metal shapes by forcing a sheet of metal or flow between a male die and female die. Some drawn parts involve the use of several dies in sequence, each producing a portion of the desired form change. Drawing is distinguished from stamping primarily in that it is used on heavier gauges of metal, produces more plastic flow of the metal, and proceeds more slowly to avoid tearing.

49. Extrusion:	The process of causing metals or plastics to flow plastically through a forming die under the simultaneous application of heat and pressure.

MATERIAL REMOVING OPERATIONS

Operations 50 through 57 are machining operations used on metals, plastics, and wood, although the terms used here apply specifically to metals. The different operations listed merely involve different orientations of cutting surfaces relative to one another, and different methods of holding and moving them relative to the work.

50. Turning:	In this operation cylindrical forms are produced as skewed cylinders, i.e., screws. The work is turned at high speed about a stationary axis, and a single cutting surface moving at a relatively low speed radially and axially relative to the work peels off substantially continuously a thin slice of material.
51. Shaping and Planning:	A single cutting tool takes repeated rectilinear passes over the work, taking off a thin slice of material at each pass. Generally, the work advances slowly, either rectilinearly or rotationally under the tool and at right angles to tool motion. Additionally, the tool may advance or retract perpendicularly to both of these motions in order to produce such shaped parts as spur gears.
52. Drilling:	Cutting holes by advancing a rotating cutting tool axially into the work. The cutting tool normally has two cutting surfaces roughly forming elements of a cone at the end of the tool.
53. Boring:	Improving the roundness and straightness of an existing hole by advancing into it a single cutter which takes a relatively light cut along the cylindrical surface of the hole. Either the tool or the work is rotated about an axis corresponding to the desired centerline of the hole. Essentially, this is an inside-out version of turning, and is used to put shoulders and other departures from straight cylindrical sides in a hole, as well as to form precise, straight holes.

Appendix H cont'd.

54. Milling:	Removal of material by use of a high-speed rotary cutter with many cutting surfaces on it, in the shape of a ball, a flat-sided, flat-ended cylinder, or a wheel. The rotating cutter advances relatively slowly over the work, with the side of the ball, the side or end of the cylinder, or the periphery of the wheel cutting as it goes.
55. Broaching:	Drawing a many-element cutter over or through a hole in work, with each element taking a little or more material off than its predecessor. Operation is like a combination of shaping and planing in one pass of the tool, because that one pass makes many cuts.
56. Sawing:	Drawing a thin, many-toothed cutter rotating at high speed around an axis perpendicular to the line of a desired cut, advancing it relatively slowly along the line of the desired cut.
57. Grinding:	Milling with an abrasive wheel, making repeated passes of the wheel over the work and taking a very light cut with each pass.

FURTHER MISCELLANEOUS OPERATIONS

58. Etching:	Removal of material by bringing it into contact with a liquid reagent chemical. Usually an etched pattern is desired, and so portions of the work are masked with a material which is not attacked by the reagent.
59. Molding:	Melting material, causing it to flow, and then freezing it under simultaneous application of heat and pressure in a die or mold. Widely used with plastics.
60. Vacuum Form and Blow:	Heating a thermoplastic, usually in sheet form, to the point where it flows relatively easily, and by application of air pressure, causing it to flow as a bubble into a mold or die of desired shape.

Appendix H cont'd.

61. Lamination:	Gluing together thin sheets of similar or dissimilar materials into a sandwich under simultaneous application of heat and pressure.
62. Cutting:	The use of knives, scissors, ribbon dies, and similar shearing tools to form thin sheets of material into contoured shapes.
63. Shearing:	Use of a single knife operating in conjunction with a fixed blade in action somewhat like a scissors, to make straight cuts in sheet materials which may be too heavy for the cutting operation, 62 above.
64. Combing:	Rearrangement of randomly deployed, relatively short, straight fibers so that they lie parallel to one another. An important operation performed in large concentric drums with teeth protruding from the inner surface of the outer drum and the outer surface of the inner drum into a region filled with fibers. An early step in yarn and thread making.
65. Spinning:	Drawing a number of filaments from a source of combed fibers and twisting the fibers into thread.
66. Winding:	Rolling up threads, belts, or sheets of material on a bobbin or drum.
67. Felting:	Compressing a random array of fibers, usually carried in a liquor, into a cohesive sheet by the simultaneous application of heat and pressure.
68. Warping:	Drawing a flat web of unwoven threads or pieces of yarn from a creel.
69. Knitting:	Forming yarn into finished shapes of such articles as stockings, underwear, sweaters, etc., by interlocking, looping, and trying the various elements of yarn to one another in a repeating pattern, intricately manipulating a series of needles with the yarn strung and looped on them for this purpose. Used to form topologically complex, relatively elastic sheets of cloth.

Appendix H cont'd.

70. Braiding:	Interwinding and looping a relatively small number of individual webs of thread, strips of leather, etc., in a repeating pattern in which all elements lie more nearly parallel to one another than perpendicular to one another. Generally used to form long, thin, flat belts of material.
71. Weaving:	Interlacing pieces of straight thread or yarn into a tightly locked matrix in which roughly half of the elements lie parallel to one another and perpendicular to the other half. Result is flat sheets of relatively inelastic cloth.
72. Buffing:	Abrading a surface to be finished with a relatively rough tool (high-speed wire or fiber brush, sandpaper, etc.).
73. Polishing:	Finishing a surface by rubbing it with a very fine abrasive powder at low speeds, sometimes followed by rubbing in a hardening and filling agent such as oil or wax.
74. De-Burring:	Removal of fine chips, rough surfaces and, particularly, rough edges of machined metal parts by abraiding them with sand carried in an air blast, tumbling the parts in a drum containing metal pellets, etc.
75. Painting:	Application of a film of a drying liquid to a surface: by spreading it by means of a brush, roller, squeegee, or knife; by dipping the surface into a bath of liquid; or by spraying.
76. Printing:	To lay down ink, dye, or paint in a pattern, which may be either alpha-numeric characters, pictorial, or abstract, on a surface. The process involves coating a patterned, raised surface with the ink, dye, or paint, and pressing it against the material to which the print is to be transferred, or by selective transmission of the imprint material through a mask.
77. Dyeing:	Passing bivrous materials through a colored liquid which wets and impregnates the fibers with a coloring pigment, coloring them more or less permanently when the liquid has dried.

78. Calender Coating:	Pressing a coating, such as plastic, clay or rubber, into a fibrous substrate such as paper or cloth, under the simultaneous application of heat and high pressure between rollers. Purpose is to change surface properties of substrate.
79. Electroplating:	Deposition of a thin coat of one metal onto another metal by immersing both metals in a properly chosen ionizing solution and passing an electric current between them so that ions of the one metal migrate to the surface of the other.
80. Oxide Coating:	Similar to electroplating, except that the electrodes and the communicating solution are chosen so that an oxide of the metal to be coated is formed at its surface, rather than a coating of another metal.
81. Porcelain Enamelling:	Coating a surface with powdered ceramic carried in a liquid or paste, and then fusing it into a high-glaze surface by the application of intense radiant heat.
82. Locating:	Positioning an object in one or more of its three rectilinear degrees of freedom.
83. Orienting:	Positioning an object in one or more of its three rotational degrees of freedom.
84. Filling:	Putting material into a container.
85. Evacuating:	Removing material from a container.

FASTENING OPERATIONS

86. Welding:	To join metal pieces together by fusion at high temperature, either by heating generally or by the application of local heat sufficiently intense to liquefy and fuse metal on both pieces in the immediate vicinity of joint, as well as metal, which may or may not be added in order to fill up the joint. Heat is applied by various means including an electric arc established between a rod of metal to be liquefied and added and the pieces to be joined, a gas torch or furnace, or an electric current passing through points of contact between pieces to be joined.

87. Brazing and Soldering:	To join metal pieces by melting and causing to flow over and into the joint by capillary action a filler metal or lower melting point than the metals being joined. The metals being joined are not fused. Soldering is differentiated from brazing only by the fact that filler metals are of lower melting point. The arbitrary differentiating temperature is 800° F.
88. Pinning:	Fastening two materials by insertion of a rod through apertures in the materials. Includes attachment by screws, bolts, rivets, staples, nails, and tacks. The holding forces may be frictional, as with nails and screws, or may arise from the final geometry of the pin, as with rivets, bolts, and staples.
89. Sewing:	Fastening fibrous materials together by running a thread back and forth through them locking elements of the two to be fastened together in loops of the stitching thread, and tying the thread if necessary.
90. Seaming and Curling:	Fastening a thin sheet of metal to another or to a lip in another part by bending the thin pieces around one another in a folded lap joint or bending the thin piece over the lip in the mating piece. Usually using a rolling tool.
91. Shrinking:	Fastening two parts together by dimensioning them for an interference fit, heating one part to expand it, perhaps cooling the other to contract it, until the hot one will slide over the cold. It then shrinks as it cools, and forms a prestressed friction bond. Usually used to mate around parts.
92. Pressing:	Fastening two parts together which are dimensioned for an interference fit, by pressing the one into the other on an arbor.
93. Gluing:	Fastening two parts together by coating the mating surfaces with adhesive placing them in contact and allowing the glue to set, usually under pressure and in some cases at high temperatures.
94. Sealing:	Locking material in a container by closing off its means of exit: by tying, crimping, soldering, gluing, using a gasket and vacuum pressure, or by other means.

Appendix I

LEONTIEF'S INTER-INDUSTRY ECONOMIC MODEL

FINAL NONMETAL

1. Footwear and Other Leather Products
2. Miscellaneous Furniture and Fixtures
3. Household Furniture
4. Tobacco Manufactures
5. Apparel
6. Miscellaneous Fabricated Textile Products
7. Drugs; Cleaning and Toilet Preparations
8. Food and Kindred Products

FINAL METAL

9. Special-Industry Machinery and Equipment
10. Ordnance and Accessories
11. Aircraft and Parts
12. Miscellaneous Transportation Equipment
13. Radio, Television and Communication Equipment
14. Materials-Handling Machinery and Equipment
15. Miscellaneous Manufacturing
16. Optical, Ophthalmic and Photographic Equipment
17. Service-Industry Machines
18. Household Appliances
19. Scientific and Controlling Instruments
20. Office, Computing and Accounting Machines
21. Farm Machinery and Equipment
22. Engines and Turbines
23. Construction, Mining and Oil-Field Machinery
24. Miscellaneous Electrical Machinery, Equipment and Supplies
25. Metalworking, Machinery and Equipment
26. Motor Vehicles and Equipment
27. General Industrial Machinery and Equipment
28. Electric-Lighting and Wiring Equipment
29. Electric Industrial Equipment and Apparatus
30. Electronic Components and Accessories

Appendix I con't.

BASIC METAL

31. Heating, Plumbing and Structural-Metal Products
32. Machine-Shop Products
33. Metal Containers
34. Stampings, Screw-Machine Products and Bolts
35. Other Fabricated Metal Products
36. Primary Nonferrous Metal Manufacturing
37. Nonferrous Metal Ores Mining
38. Primary Iron and Steel Manufacturing
39. Iron and Ferroalloy Ores Mining

BASIC NONMETAL

40. Stone and Clay Products
41. Stone and Clay Mining and Quarrying
42. Printing and Publishing
43. Glass and Glass Products
44. Paperboard Containers and Boxes
45. Paper and Allied Products, Except Containers
46. Wooden Containers
47. Lumber and Wood Products, Except Containers
48. Forestry and Fishery Products
49. Miscellaneous Textile Goods and Floor Coverings
50. Rubber and Miscellaneous Plastics Products
51. Broad and Narrow Fabrics, Yarn and Thread Mills
52. Paints and Allied Products
53. Leather Tanning and Industrial Leather Products
54. Livestock and Livestock Products
55. Miscellaneous Agricultural Products
56. Agricultural, Forestry and Fishery Services
57. Plastics and Synthetic Materials
58. Chemicals and Selected Chemical Products
59. Chemical and Fertilizer, Mineral Mining

ENERGY

60. Petroleum Refining and Related Industries
61. Electricity, Gas and Water
62. Coal Mining
63. Crude Petroleum and Natural Gas

Appendix I con't.

SERVICES

64. Federal Government Enterprises
65. Transportation and Warehousing
66. State and Local Government Enterprises
67. Hotels; Personal and Repair Services, Except Automobile
68. Automobile Repair and Services
69. Radio and Television Broadcasting
70. Amusements
71. Medical and Educational Services; Nonprofit Organizations
72. Wholesale and Retail Trade
73. Finance and Insurance
74. Communications, except Radio and Television Broadcasting
75. Business Services
76. Real Estate and Rental
77. Maintenance and Repair Construction

MISCELLANEOUS

78. Research and Development
79. Office Supplies
80. Business Travel, Entertainment and Gifts
81. Scrap, Used and Secondhand Goods

Appendix J

CURRICULUM PROJECTS REVIEWED

ANTHROPOLOGY CURRICULUM STUDY PROJECT
5632 South Kimbark Ave., Chicago, Illinois.......Dr. Malcolm Collier

BIOLOGICAL SCIENCE CURRICULUM STUDY
University of Colorado, Boulder, Colorado..... Dr. Arnold B. Grobman

CHEMICAL BOND APPROACH PROJECT
Earlham College, Richmond, Indiana............Dr. Laurence E. Strong

EARTH SCIENCE CURRICULUM PROJECT
University of Colorado, Boulder, Colorado..........Dr. R. L. Heller

ELEMENTARY SCIENCE STUDY
108 Water Street, Watertown, Massachusetts....Dr. Benjamin Nichols

ELEMENTARY SCHOOL SCIENCE PROJECT
University of California
2232 Piedmont Avenue
Berkeley, California.............................Dr. Leo Brewer

ELEMENTARY SCHOOL SCIENCE PROJECT
University of Illinois
805 West Pennsylvania Avenue
Urbana, Illinois.................................Dr. J. Myron Atkin

ENGINEERING CONCEPTS CURRICULUM PROJECT
Polytechnic Institute of Brooklyn
333 Jay Street
Brooklyn, New York..............................Dr. J. G. Truxal

HIGH SCHOOL GEOGRAPHY PROJECT
Montana State College
Bozeman, Montana..........................Dr. Nicholas Helburn

MUSIC IN GENERAL EDUCATION
National Education Association
1201 Sixteenth Street Northwest
Washington, D. C.
Other related projects: "Contemporary Music Project"
and "Elementary School Music"................Dr. Charles L. Gray

ORGANIC CURRICULUM: ECONOMIC EDUCATION
Industrial Administration
Purdue University
Lafayette, Indiana.........................Dr. Lawrence Senesh

Appendix J - cont'd.

PHYSICAL SCIENCE STUDY COMMITTEE
Educational Services Incorporated
164 Main Street
Watertown, Massachusetts................Dr. Uri Haber-Schaim

SCIENCE - A PROCESS APPROACH
American Association for the Advancement of Science
1515 Massachusetts Avenue, Northwest
Washington, D. C.........................Dr. Paul B. Sears

SCIENCE CURRICULUM IMPROVEMENT STUDY
Department of Physics,
University of California
Berkeley, California.......................Dr. Robert Karplus

SCHOOL HEALTH EDUCATION STUDY
National Educational Association
1201 Sixteenth Street, Northwest
Washington, D. C. ....Dr. Elena M. Sliepcevich

SCHOOL MATHEMATICS STUDY GROUP
School of Education, Stanford University
Stanford, California.....................Dr. Edward G. Begle

SECONDARY SCHOOL SCIENCE PROJECT
Department of Geology
Princeton University
Princeton, New Jersey.................Dr. Frederick L. Ferris, Jr.

SOCIOLOGICAL RESOURCES FOR SECONDARY SCHOOLS
Dartmouth College
Hanover, New Hampshire................Dr. Robert Feldmesser

UNIVERSITY OF ILLINOIS COMMITTEE ON SCHOOL MATHEMATICS
1210 West Springfield
University of Illinois
Urbana, Illinois............................Dr. Max Beberman

WORLD HISTORY PROJECT
Department of History
College of Arts and Sciences
Northwestern University
Evanston, Illinois..........................Dr. L. S. Stavrianos

Appendix K

SCHOOL HEALTH EDUCATION STUDY

Key Concepts	Concepts
A. GROWING AND DEVELOPING	1. Body structure and function influences growth and development and vice versa.
	2. Growth and development follows a predictable sequence, yet it is unique for each individual.
B. DECISION MAKING	1. Personal health practices* are affected by a complexity of forces, often conflicting.
	2. Use of health information, products, and services is governed by the application of an individual's criteria.
	3. Use of stimulants and depressants arises from a variety of motivations.
	4. Food selection and eating patterns are determined by physical, mental, social, cultural, and economic factors.
C. INTERACTIONS	1. Protection and promotion of health is an individual, family, and community concern.
	2. Whatever the environment, the potential for hazards and accidents exists.
	3. There is a reciprocal relationship between man, disease, and environment.
	4. The family is the basic unit of society through which certain health needs can be fulfilled.

(Key concepts and concepts are interdependent.)

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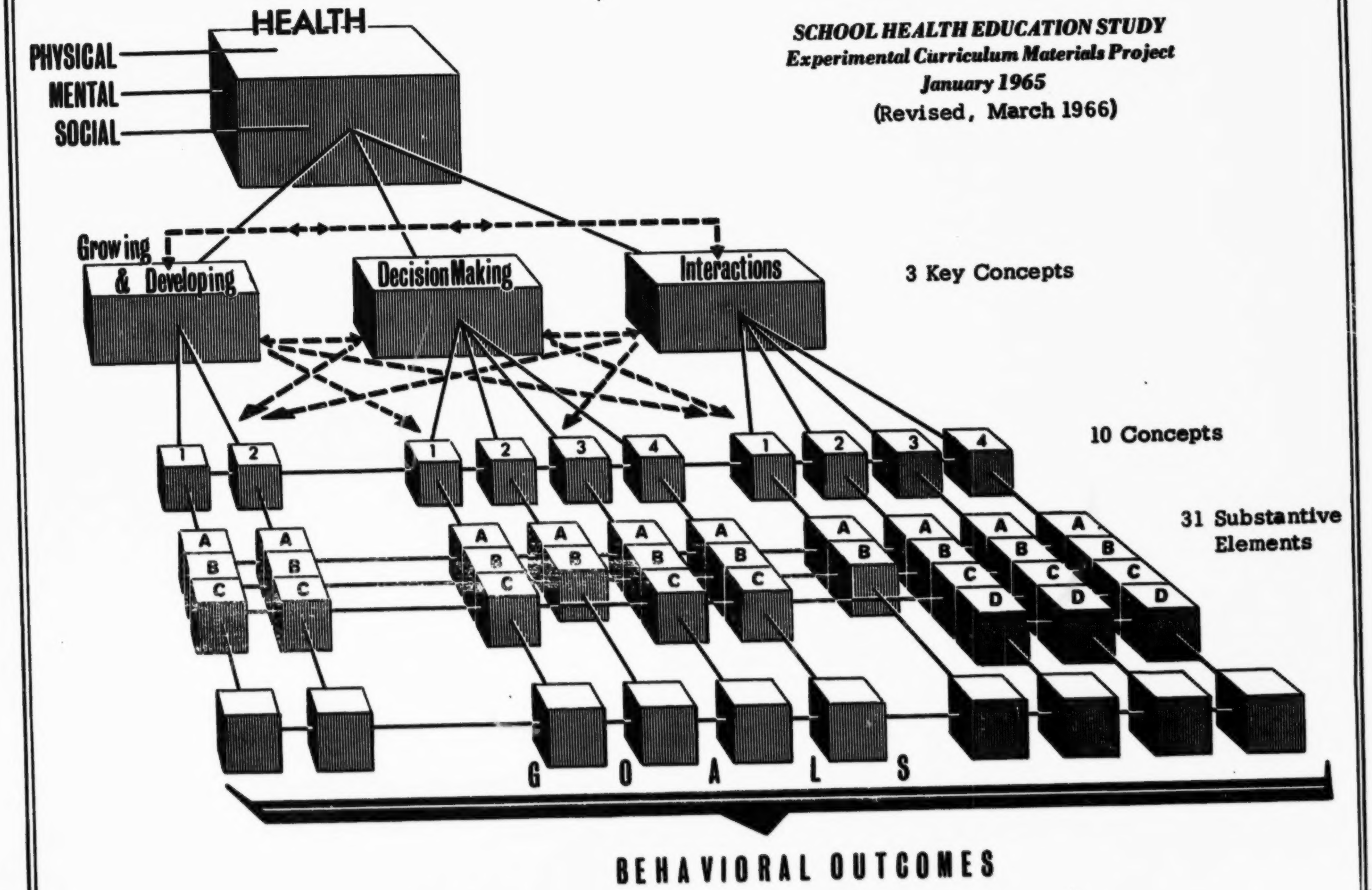
*Personal health practices as used here encompass sleep, relaxation, activity, posture, skin care, dental health, and personal appearance.

School Health Education Study
Revised 9-15-65

Appendix K con'd.

SCHOOL HEALTH EDUCATION STUDY
Experimental Curriculum Materials Project
January 1965
(Revised, March 1966)


HEALTH
PHYSICAL
MENTAL
SOCIAL
Growing & Developing
Decision Making
Interactions
3 Key Concepts
1
2
1
2
3
4
1
2
3
4
10 Concepts
A
B
C
D
31 Substantive Elements
GOALS
BEHAVIORAL OUTCOMES

A Conceptual Model for Health Education

Grades Kindergarten through Twelve

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Appendix L

ORGANIC CURRICULUM - ECONOMIC EDUCATION

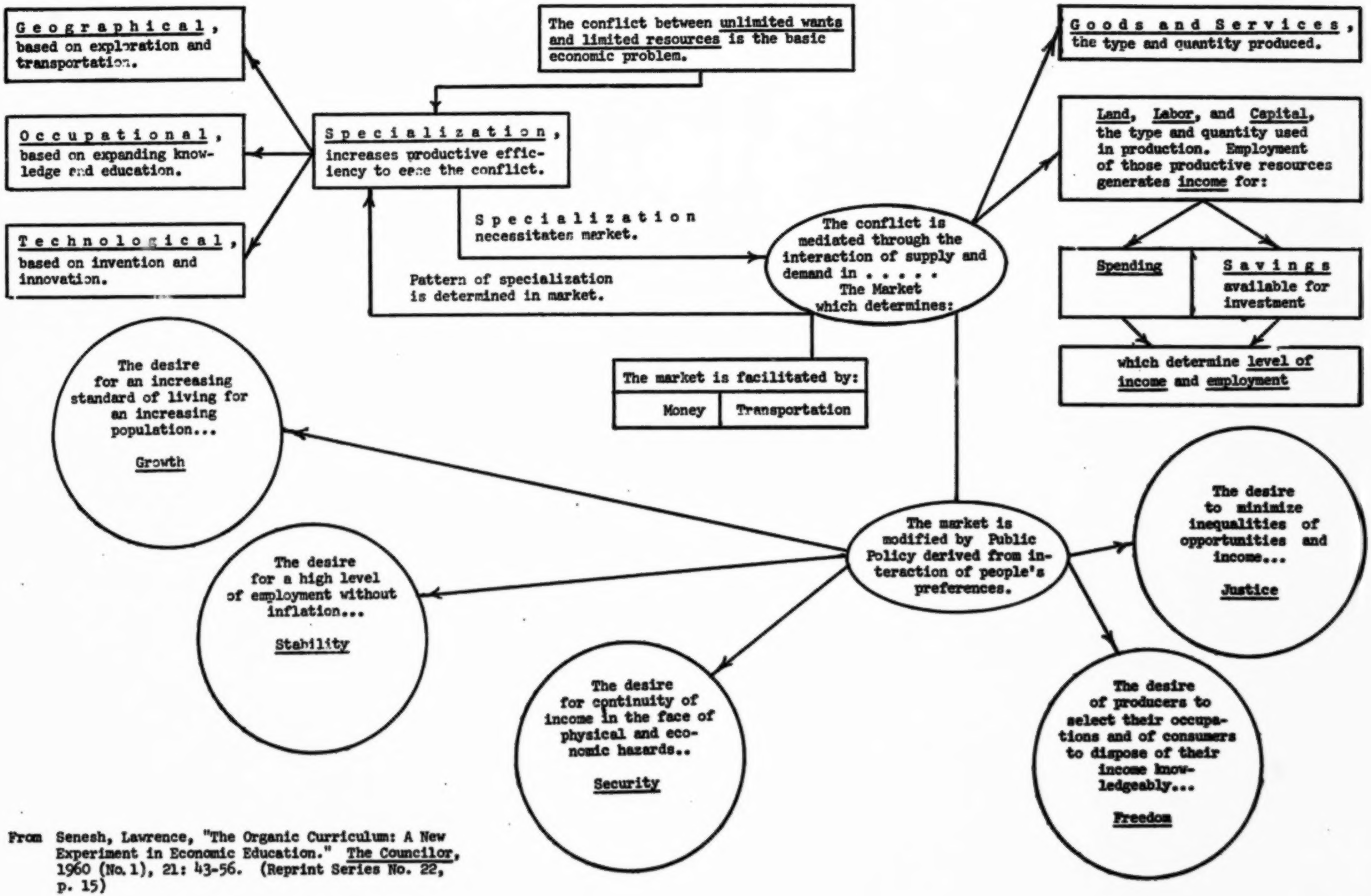
The organic curriculum rests upon the idea "that children on every grade level, with proper motivation, can become excited about the abstract ideas underlying their experiences, and that these ideas can be presented in such a way as to reflect the basic structure of the body of economic knowledge."

Basic ideas include

1. unlimited wants and limited resources
2. man made systems for overcoming the above conflict
3. basic questions involving; what goods and services, how quantity to be produced, who will receive goods and services
4. United States Viewpoint - free choice of either consumer or participants in the production process
5. United States viewpoint - limit free choice for the general welfare.

Appendix L

THE FUNDAMENTAL IDEA RELATIONSHIPS OF ECONOMIC KNOWLEDGE


The conflict between unlimited wants and limited resources is the basic economic problem.
Specialization, increases productive efficiency to ease the conflict.
Geographical, based on exploration and transportation.
Occupational, based on expanding knowledge and education.
Technological, based on invention and innovation.
Specialization necessitates market.
Pattern of specialization is determined in market.
The conflict is mediated through the interaction of supply and demand in . . . . . The Market which determines:
Goods and Services, the type and quantity produced.
Land, Labor, and Capital, the type and quantity used in production. Employment of those productive resources generates income for:
Spending
Savings available for investment
which determine level of income and employment
The market is facilitated by:
Money
Transportation
The market is modified by Public Policy derived from interaction of people's preferences.
The desire for an increasing standard of living for an increasing population... Growth
The desire for a high level of employment without inflation... Stability
The desire for continuity of income in the face of physical and economic hazards.. Security
The desire of producers to select their occupations and of consumers to dispose of their income knowledgeably... Freedom
The desire to minimize inequalities of opportunities and income... Justice

From Senesh, Lawrence, "The Organic Curriculum: A New Experiment in Economic Education." The Councilor, 1960 (No. 1), 21: 43-56. (Reprint Series No. 22, p. 15)